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A METHOD OF CLASSIFYING THE INORGANIC ACIDS FOR ANALYSIS.*

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It is safe to assert that an entirely satisfactory method for the analysis of the acids is yet to be formulated. The following method is one which I have used with my students, in a more or less modified form, for several years with good results, and I venture to present it thinking it may interest those who are teachers of chemistry.

As we all know the separation of the acids is not as easily effected as the separation of the bases, since their grouping is not so distinct and since they are not so readily separated by precipitation and filtration.

In this classification the groups of the acids are successively precipitated and separated by the use of solutions of the salts of an organic acid thus eliminating the use of an inorganic acid. This method includes the detection of some twenty inorganic and a few organic acids.

PREPARATION OF THE SOLUTION.

If necessary treat the solution with H_2S to remove the metals of the first two groups. Filter, boil to expel H_2S gas from the filtrate and add a slight excess of Na_2CO_3.

Boil, filter while hot, wash and reserve the precipitate which may contain silicic, phosphoric and oxalic acids.

The filtrate contains all the acids present except the silicates, phosphates, oxalates, and perhaps the fluorides. While still hot

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expel from the filtrate the excess of CO_2 by acidifying with acetic acid and finally neutralize the solution with the least possible amount of NH_4OH.

EXAMINATION OF THE NA_2CO_3 PRECIPITATE FOR SILICIC, PHOSPHORIC AND OXALIC ACIDS.

Treat one portion of the precipitate with HNO_3 and evaporate the solution to dryness. Digest the residue with water, add HNO_3 and filter. A white gritty powder which when fused in a bead of "microcosmic salt" dissolves and floats in the bead, shows the presence of silicic acid.

To the above filtrate add an excess of ammonium molybdate in nitric acid, warm and let the test stand. The formation of yellow crystalline ammonium phosphomolybdate, shows the presence of phosphoric acid.

Treat another portion of the precipitate with acetic acid and filter to remove any insoluble residue. Boil the filtrate to remove all traces of CO_2, and then add $CaSO_4$ or $CaCl_2$. A white powdery precipitate shows the presence of oxalic acid. If a fluoride were present the precipitate with these reagents would be gelatinous and nearly colorless.

If silicates and fluorides are both present they will likely combine forming either silicon fluorides or hydrofluosilicic acid.

GROUPS OF THE ACIDS.

Group I.

Acids decomposed by the stable mineral acids with the evolution of a gas.

Carbonic evolves CO_2 which clouds lime water.
Sulphurous evolves SO_2 which has the odor of burning sulphur.
Nitrous evolves NO which forms brown fumes with the air.
Hydrosulphuric evolves H_2S which has a stale egg odor.
Hydrocyanic evolves HCN which has a bitter almond odor.
Acetic evolves $HC_2H_3O_2$ with H_2SO_4 and forms a red solution with $FeCl_3$.

Group II.

Acids precipitated from neutral solutions by Calcium Acetate.

Arsenious, white, soluble in excess or in acetic acid.
Boric, white, soluble in excess or in acetic acid.
Carbonic, white, soluble in acetic acid with effervescence.
Hydrocyanic, white, soluble in excess or in acetic acid.

Phosphoric, white, soluble in acetic acid.
Tartaric, white, soluble in acetic acid.
Hydrofluoric, white, insoluble in acetic acid.
Oxalic, white, insoluble in acetic acid.
Silicic, white, insoluble in acetic acid and in all dilute acids.

Group III.

Acids precipitated by Barium Acetate.

Chromic, yellow, soluble in warm HCl.
Sulphuric, white, insoluble in HCl or HNO_3.

Group IV.

Acids precipitated by Silver Acetate in the presence of acetic acid or by Silver Nitrate in the presence of nitric acid.

Hydroferrocyanic, white, soluble in KCN: insoluble in NH_4OH.
Sulphocyanic, white, curdy, soluble in NH_4OH.
Hydroferricyanic, orange red, soluble in NH_4OH and in KCN.
Hydrocyanic, white, soluble in KCN and in NH_4OH
Hydriodic, light yellow, slightly soluble in NH_4OH, easily in KCN.
Hydrobromic, yellowish white, difficultly in NH_4OH, soluble.
Hydrochloric, white, curdy, easily soluble in NH_4OH.
Hydrosulphuric, black, soluble in hot dilute HNO_3.

Group V.

Acids not precipitated in the preceding groups.

Arsenious gives yellow As_2S_3 with H_2S in presence of HCl or $HC_2H_3O_2$.
Chloric gives a deep blue color with aniline sulphate and H_2SO_4.
Nitric gives the "brown ring" test.

Analysis of the Acids in Solution.

Use one third of the solution for the detection of the acids of Group I and the main portion for the detection of the acids of the other groups.

Group I.

This group includes the CO_3, SO_3, S, NO, $C_2H_3O_2$ and CN ions which are liberated by such dilute acids as HCl or HNO_3.

1. CO_3. To a portion of the solution add a few drops of HCl. Effervescence and the evolution of a gas which clouds a drop of lime water shows the presence of carbonic acid.

2. SO_3. To a second portion add HCl and warm. The evolution of a gas having the odor of burning sulphur shows the presence of sulphurous acid. Thiosulphuric acid gives a white or yellow precipitate of sulphur in addition to evolving SO_3.

3. NO. Acidify a third part with acetic acid or dilute H_2SO_4 and add some $FeSO_4$. A yellow brown or black brown coloration shows the presence of nitrous acid.

4. S. Acidify another portion with HCl and warm. If a gas is liberated which has a stale-egg odor or which blackens a strip of "lead acetate paper," H_2S is present.

5. $C_2H_3O_2$. To a fifth portion add a little alcohol, a few drops of conc. H_2SO_4 and gently warm. The formation of ethyl acetate which has a characteristic odor shows the presence of acetic acid. Apply this test in the absence of chlorates, chromates, cyanides, and iodides.

6. CN. See Group IV, A (4).

Group II.

This group contains the acids which are precipitated from neutral solutions by Calcium Acetate.

A. Boric, Phosphoric, Carbonic, Hydrocyanic and Tartaric acids which are soluble in acetic acid.

B. Hydrofluoric, Oxalic and Silicic acids which are insoluble in acetic acid.

To the major portion of the solution add conc. aqueous calcium acetate $Ca(C_2H_3O_2)_2$ in very slight excess. A white precipitate shows the presence of one or more members of this group. Filter, wash the precipitate twice with cold water and reserve the filtrate and washings for treatment under the next group.

Treat the precipitate on the filter with acetic acid passing the acid solution through the filter as long as any of the precipitate dissolves. Wash any insoluble residue twice with cold water and treat the filtrate under A and the residue under B.

A.

Divide A into four portions. Note that CN and CO_3 are both precipitated by calcium acetate but the former is more or less soluble in water and both are decomposed by acetic acid, causing effervescence in the case of a carbonate and giving the odor of bitter almonds with a cyanide (poison).

1. BO_3. Evaporate one portion to about one half its volume and acidify it with normal HCl. Saturate a strip of turmeric paper with this solution and dry it at a gentle heat. If the strip assumes a pale rose-red color which in turn becomes greenish-black on adding a drop of KOH, boric acid is present.

2. PO_4. To a second portion add an excess of an ammonium molybdate solution, warm and let stand. A yellow crystalline precipitate shows the presence of phosphoric acid. Arsenic acid gives a similar precipitate.

3. $C_4H_4O_6$. Evaporate a third portion to dryness, add a drop or so of conc. H_2SO_4 and again heat. If the residue blackens and yields an odor of "burnt sugar," tartaric acid is present.

Since boric acid redissolves somewhat after being precipitated by calcium acetate, it will be necessary to test for it again under Group V.

B.

1. F. Test a portion of the residue which was insoluble in acetic acid as follows: Cover a piece of window glass or a small watch glass with a thin coating of wax and when the wax is cold remove a portion of it with some sharp instrument. Mix the residue to be tested with enough conc. H_2SO_4 to make a paste and cover the exposed parts of the glass with the mixture. Let the test stand for fifteen minutes, then clean the glass and see if it has been etched where exposed. If so, hydrofluoric acid is present.

2. C_2O_4. Place another portion of the residue in a test-tube with a little MnO_2 and cover it with H_2SO_4. While boiling hold in the escaping vapor a drop of clear lime water on the end of a glass rod. If the drop becomes cloudy due to the liberation of CO_2, oxalic acid is present.

3. SO_2. Treat a third portion with HCl and evaporate to dryness. Digest the residue with H_2O and HCl and filter. A white gritty insoluble powder indicates silicic acid as SiO_2. See page 2.

Group III.

This group contains Chromic and Sulphuric acids which are precipitated from the filtrate of Group II by Barium Acetate.

To the filtrate from Group II add a slight excess of barium acetate Ba $(C_2H_3O_2)_2$ and agitate. A fine white precipitate shows the presence of sulphuric acid and in that case, filter and pass to the next group. A fine yellow precipitate indicates chromic acid. If a precipitate forms, filter, wash, and reserve the filtrate for treatment under Group IV.

1. CrO_4. Transfer the precipitate to a test tube and warm with dilute HCl. Any chromate present will dissolve to a yellow solution, the white sulphate when present remaining undissolved. Filter, wash and confirm the presence of chromic acid by acidifying with acetic acid and adding lead acetate for yellow lead chromate.

2. SO_4. Any white residue insoluble in dilute HCl or HNO_3 confirms the presence of sulphuric acid.

Group IV.

This group contains Hydroferrocyanic, Sulphocyanic, Hydroferricyanic, Hydrocyanic acids classified under portion A and Hydriodic, Hydrobromic, Hydrochloric acids, classified under portion B, which are precipitated by Silver Acetate from acetic acid solutions or by Silver Nitrate from nitric acid solutions.

Strongly acidify the filtrate from the last group with acetic acid, add silver acetate in slight excess and gently warm, not boil. Filter, wash twice and reserve the filtrate for later treatment. Divide the precipitate into two portions "A" and "B."

Portion A.

Agitate "A" with a mixture of one part of dilute HCl and three parts of a solution of sodium chloride (1—10) which dissolves the cyanides. Filter and reject the precipitate. Divide the filtrate into three parts.

1. $Fe(CN)_6''''$. To one portion add $FeCl_3$ as long as a precipitate forms. A dark blue precipitate shows the presence of hydroferrocyanic acid. Filter.

2. CNS. If the filtrate from (1.) has a blood red color which is destroyed by $HgCl_2$, sulphocyanic acid is present.

3. $Fe(CN)_6'''$. To a second portion add a crystal of $FeSO_4$ or a freshly prepared solution of $FeSO_4$. A dark blue precipitate shows the presence of hydroferricyanic acid. Or the filtrate from (1) may be boiled with H_2SO_3 and more $FeCl_3$ added. A dark blue precipitate shows the presence of the acid.

4. CN. To a third portion add a little picric acid, and excess of NH_4OH and warm. If on standing a light or dark mahogany color appears, hydrocyanic acid is present.

Portion B.

Place portion "B" of the precipitate in an evaporating dish with a few pieces of zinc, cover with water, add a few drops of H_2SO_4 and gently warm. When the reduction of the silver salts is complete, indicated by a black precipitate, filter and reject the precipitate. Neutralize the filtrate with Na_2CO_3, filter, reserve the filtrate and reject the precipitate.

1. I and Br. Test a portion of the filtrate as follows: Add to the test an equal volume of CS_2 and then nitro-sulphuric acid (1:1) drop by drop, vigorously agitating after the addition of each drop and noting the color of the CS_2. If the latter becomes pink or violet, HI is present; if yellow, yellow-brown or red-brown, HBr is present. The iodine is first liberated and the colored sulphide may be removed by filtering. To the filtrate add more CS_2 and repeat the operation. When all the I has been removed any liberated Br will in turn color the CS_2.

2. Acidify a second portion of the solution with HNO_3 and add $AgNO_3$ in slight excess. Filter, wash, reject the filtrate and boil the precipitate with an excess of "sesqui" ammonium carbonate. Decant the clear liquid, add a fresh portion of the carbonate and again boil. Decant as before and to the decanted liquids add enough HNO_3 to acidify. The formation of a white curdy precipitate shows the presence of hydrochloric acid. (Hager's Test.)

In the absence of HI and HBr add to the test solution $AgNO_3$. A white curdy precipitate which is insoluble in HNO_3 and which readily dissolves in NH_4OH, shows the presence of HCl.

NOTE 1. When $AgNO_3$ is used as the group reagent the procedure is unchanged except that HNO_3 must be detected in Group I. Interfering acids are nitrous, chloric, ferro and ferricyanic, sulphocyanic and the halogen acids.

Group V.

This group contains Arsenious, Chloric and Nitric acids which are not precipitated in the preceding groups, being soluble.

1. ClO_3. To a minor portion of the filtrate from the last group, add a piece of zinc, a few drops of HNO_3 and gently warm. A white curdy precipitate of AgCl shows the presence of chloric acid. Or to a portion of the filtrate add a little formalin, a few drops of HNO_3 and heat, a white curdy precipitate shows the presence of $HClO_3$. In both these tests there must be present an excess of the silver salt.

Remove the silver from the main portion of the filtrate from Group IV by adding a solution of NaCl as long as a precipitate forms. Filter, wash, reject the precipitate and test the filtrate as follows:

2. As_2O_3. Acidify the filtrate with acetic acid and saturate it with H_2S. If a yellow precipitate forms at once, arsenious acid is present. Filter, wash, and treat the filtrate under 3. (Omit test if arsenic was found in the analysis of the metals.)

3. Concentrate the filtrate to a convenient volume to expel H_2S and in case chloric acid is present apply the "brown ring" test directly. Add an equal volume of conc. H_2SO_4 to the test so that the two liquids will not mix, cool and pour down the side of the tube some $FeSO_4$ solution. Let the test stand for some minutes undisturbed. The formation of a brown or dark brown ring at the juncture of the acid and the test solution, shows the presence of nitric acid. Nitrous acid gives the "ring" with acetic acid in place of the H_2SO_4.

4. To detect HNO_3 in the presence of $HClO_3$, acidify the concentrated filtrate, or a portion of it from 3 with acetic acid, boil for a minute with an excess of H_2SO_3. Filter if necessary, reject any precipitate and to a portion of the clear liquid add a drop or two of diphenylamine in conc. H_2SO_4. If a blue color appears at once, HNO_3 is present. This color slowly disappears.

This test depends upon the action of the sulphurous acid in changing any chlorate present into a chloride. To determine whether all the chlorate has been changed, add to the remaining portion of the solution a drop or two of aniline and then a few drops of conc. H_2SO_4. A blue color appears at once if any chlorate is present in which case use more of the H_2SO_3. The appearance of a blue color with this test serves to detect a chlorate in the presence of a nitrate. The aniline test gives with a nitrate a yellow brown color.

5. BO_3. To another portion of the filtrate apply the test for boric acid given under Group II, A, 1.

THOUGHTS ON THE PRACTICAL USE OF THE METRIC SYSTEM.

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There have been many discussions of the advantages of the metric system of weights and measures by people who are very evidently in favor of the same, and, in most cases, they are men with considerable scientific or academic training. There have also been discussions, (sometimes) in opposition, by business men who are eminently practical in commercial pursuits, but who evidently do not take a very broad view of the situation. It would seem as though the subject might be profitably discussed by one who has had enough work in manufacturing to enable him to see the apparent difficulties on the practical side, and who, at the same time, is sufficiently in touch with academic work to enable him to appreciate the obvious advantages from the scientific aspect. From this introduction, it will be properly inferred that the writer is heartily in favor of the metric system and its introduction into this country, but also that we must recognize there are some objections which, while valid, are not insurmountable.

Comparing the present social condition with that of one hundred, or even fifty years ago, one cannot avoid noticing that the world, as far as communication is concerned, is growing very much smaller. People of different nationalities are becoming better acquainted, and various means have contributed to bring about this result. Civilization has increased and extended to many lands, transportation of intelligence as well as of material objects has been made swifter, surer and cheaper, and especial emphasis should be laid on the general prosperity which results in travel, thereby bringing about the mingling of different races. Many large enterprises are becoming international in character, and have correspondents and agents in many countries; but they are badly handicapped by the difference in language and customs.

Increasing intelligence has resulted in a gradual enlarging of the powers of the human mind so that the adoption of different units has become necessary. As examples, in this country, the science of gunnery has developed until 1000 yards is the unit of range, excavations are made on the basis of 1000 cubic yards, and the duty of pumping engines is expressed in foot-pounds

developed for 1,000,000 heat units supplied. While many units have grown larger, on the other hand, the refinements in manufacture have grown closer to such an extent that even the most rabid opponent of the metric system has found it necessary to adopt .001 of an inch as a definite unit. Even this unit is being subdivided, and, in shop parlance, is called a "half thousandth" or "quarter thousandth." (Attention is called to .1 of a millimeter as a far better standard.) Where units have changed, it is worthy of note that such changes are always decimal. If decimalization is desirable, why would it not be advisable to adopt a system which is purely decimal?

The introduction and adoption of new systems is inevitable to meet the broadening conditions which are constantly arising. The necessity of universal means of communication is shown in the general tendency toward decimalization not only of the English system but of all systems. The number of firms in this country using the metric system is constantly increasing, and the demand for measuring tools made to metric units has increased to such an extent that manufacturers now furnish them, not only in combination with English units, but also as purely metric instruments.

While systems of weights and measures are of great importance, there are other systems which will have to be considered before we can arrive at universal means of communication. Among them may be mentioned as of the first importance, the difference in language, which is intended to be met by the adoption, for international purposes, of Esperanto. The Christian Endeavor Society has recently adopted this language as its official means of communication, and it would seem that all societies having international connections might use it to good advantage. In the measurement of heat, it is to be hoped that the centigrade thermometer will displace all other makes, principally because it is so closely allied to the metric system. As a last word on this subject, is it too much to expect that some day we may have an international system of money values, possibly represented by about three units, not in the form of coin, but negotiable paper, the value to be fixed by delegates from all civilized countries?

Among the objections to the use of the metric system, and by these are meant really valid objections, may be mentioned the cost of changing tools and the trouble which would be inevitable

in making repairs, and in furnishing spare parts. It is possible to use both English and metric systems in the same shop. It has been done in some cases without confusion; one line of goods being manufactured under one system, and others under another system. The antagonism of the workman, which is often mentioned as one of the principal difficulties, is not so much antagonism as it is ignorance, and in nearly every case, the workman could use metric as well as English units if he would but think so. In one case which has come within the writer's knowledge, the superintendent on hiring workmen to work under this system, furnished measuring tools for the use of the workmen, told them it was a new kind of an inch, and he says that he never had the least trouble with any man on account of it.

The principal difficulty seems to be the conservatism of the people. This was not recognized until we began to develop an export trade, but now we find that our manufacturers are not willing to abide by foreign customs in regard to packing, billing, or in the matter of credit. This conservatism accounts in a large measure for the fact that they are not willing to use the system of weights and measures of the people they are trying to please. Our import trade, being so much smaller than our export, has not given us very much trouble, but a new industry has arisen which calls for fairly large imports, and it is found that the owners of foreign automobiles, all of which are made by the metric system, have great difficulty in obtaining in this country repairs or spare parts of any kind. This is particularly true in the matter of screw-threads and accompanying parts.

There are a few who honestly prefer the English system, and think that it is better than the metric system, simply comparing them as systems, and giving no attention to the troubles arising from change. There is also an honest difference of opinion regarding the desirability of a change in this country, and, of course, it must be recognized that no change can be made immediately or absolutely. The people must be educated, first, to understand the system, and, second, to use it in preference to the English system. One of the great difficulties in regard to its introduction is the fact that people are not sufficiently acquainted with it to avoid the necessity of translating everything back and forth from one system to the other. When people become sufficiently familiar with any system or any language, so they can

think in that system or language, nearly all the difficulties attending its use at once disappear. Of course the schools must be depended upon to teach the principles of the metric system to everyone, and it should be given more prominence in the lower grades than it has at present. In secondary schools we are now using the metric system entirely in physics and chemistry, but these do not seem to impress the people as being other than purely scientific attainments. In other words, people in general do not look upon physics and chemistry as being practical, and think that, being unpractical, they necessarily use unpractical units. In the schools where manual training is taught, it would be of immense advantage if the work in the laboratories, whether wood turning, forging, or machine tool work, could be done under a system of drawings, which should use metric units only. In the drawing room the metric system could be used to the entire exclusion of the English system. If anyone should argue that this would deprive a pupil of training in the system, which he would, in all probability, be obliged to use for some years to come, it may be answered that he would get sufficient training in the use of the English system in every-day life. In fact, he could not avoid it, and, as the object of the schools is to instill principles rather than particular systems, the student would be fitted to use English units if it should be desirable to do so. The large number of young men graduating from our higher technical schools, and each year entering the engineering field, are all so well grounded in this system that they will no doubt prove a potent factor toward its final adoption. If the system is to be thoroughly understood by the people, it must be taught, to the exclusion of other systems, by all the schools from the lowest to the highest.

The Idaho school for mines at Moscow, south of Spokane, has installed an assay laboratory at the state university, the building being 60 by 100 feet. The furnace room, 50 by 70 feet, contains 12 double muffle furnaces and several gasoline smelting furnaces. The metallurgical laboratory, a separate building, has a ground floor plan of 84 by 96 feet, being floored as in a mine mill. The equipment includes jigs, a stamp mill, cyanide and concentrating plants and other technical apparatus. The chemical laboratory is also complete and thoroughly modern.

A FEW DEFICIENCIES IN THE TEACHING OF MATHEMATICS.

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I need offer no apology for the title of this paper for if there were nothing to improve in our teaching of mathematics we would not be gathered here this afternoon. We are all interested in the discovery of the defects which really exist and in the means suggested for their improvement. The history of the teaching of mathematics in America is full of this onward movement toward better instruction. There has been a gradual change in the mathematical material used in the school and in the method of its presentation. Methods have been modified; material has been stricken out and material added, until now we are teaching twice as much in each branch as was taught a hundred years ago. And we are teaching it better and more thoroughly. It is the general testimony that a century ago the students who undertook the higher mathematics were so poorly prepared that they were less able than our students to grapple with the difficulties that presented themselves. In those days arithmetic, algebra, and geometry were college studies. The changing requirements of the day coupled with the increase and development of the college curriculum has resulted in marked modifications. A glance at the old texts will reveal the absence in them of many subjects which we consider of the utmost importance today. For instance in the geometries of fifty years ago original exercises for the student are not to be found, whereas today all good schools require such work of all pupils. Trigonometry such as Playfair's which was used extensively was largely geometrical. The ratio definitions of the trigonometric functions were not used until a much later date. It is only within fifteen years that there has appeared in our algebras an adequate consideration of convergency and divergency of indefinite series. The introduction of this subject is forcing out the study of continued fractions.

In this conflict for survival the less important must give way to that which is more essential. We are merely at one stage in this evolutionary process. We are being told by some that this

*Read before the Mathematics Section, Chicago and Cook County High School Teachers Association.

or that should be left out and by others that this or that should be put in; some point to defects in our work and offer suggestions for their improvement. This afternoon I wish to point out some deficiencies in the mathematical training of the pupils who pass out from under our instruction, deficiencies which seem to me to be due to certain omissions in the scope and emphasis of that instruction.

Business men, manufacturers, college professors of mathematics and science, in fact all who have to deal with the boys and girls we have trained bring forward this indictment:—inaccuracy in the actual performance of all work in which mathematics is required. Say they your students are blunderers. They may know the theory but in practice they are blunderers. There can be no question but that in the main this charge is true. To test its truth you have but to set your senior class a series of calculations involving decimals and common fractions leading say to one desired result. But it is also to be said that inaccuracy in other things is a very common fault. A perfectly accurate man is hard to find and his worth is greater than that of rubies. Inaccuracy affects all lines of work. In many cases the result is a defective product which can nevertheless be used. A coat can be worn even though the cutter be inexact. The bread may be eaten though the proportions may differ slightly from the approved standard. The chair can be sold and used though there be deviations from the lines of greatest beauty and strength.

But note the difference. A mistake of the thousandth of an inch will cause the shaft to bind and the watch to stop. An error of one in a million will throw out a summer's work in a triangulation survey. One error in addition may cause the bookkeeper a night's work. A slight mistake in the Nautical Almanac may cause hundreds of lives and the loss of millions of dollars' worth of labor.

These last are cases where results depend upon the use of mathematics. Mathematics exists for the results to be obtained from its use. I know we hear a great deal about its value as a discipline and a mind trainer. I have no time and no desire to discuss that question here, and will only say in passing that it is my firm conviction that much of this talk of general mind training is not in accord with the facts of the case.

Mathematical study trains the mind to mathematical thought but to no other. A man may be a first class reasoner in geome-

try but a faulty reasoner in every other line of thought. No! mathematics exists in the school curriculum as well as everywhere else no more for the purpose of training the mind than does English exist for that purpose. The end of language is communication and preservation. Language is a failure when it does not communicate thought.

Mathematics fails then when it does not produce correct results. An algebraic equation is a mechanism which turns out results which are predetermined and which cannot be changed after the process is once started. The result must come right if the mechanism is properly handled. And it is this result we are after and not the motion of the crank. The point I wish to enforce is this:—even though a student understands the solution of an equation, if his results are not correct his work is of no value. I repeat of *no* value. He may have gotten some pleasure and profit out of the work but he has accomplished nothing—in the language of the physicist he has done no work.

It is at such a point as this where I feel assured many teachers encourage inaccuracy. The student gives evidence that he understands the theory but his results are incorrect; it is the practice of many teachers to mark say 50 or 60 or 70 or 80 or 90 for the correct method. Such work is really valueless and deserves no credit. The student says, "can I get no credit for the know how?" "I say no, unless you can do something." The physics teacher will accept no work of that kind. The work must be within the possible degree of accuracy obtainable under the circumstances.

In my opinion we wrong the pupil when we allow him to feel that 90 per cent work is all right. The 90-per-cent-accuracy man can occupy no permanent place or be successful in any of the hundred and one vocations of the day where mathematical precision is essential, and these pursuits are increasing every day. The ever increasing differentiation of scientific and engineering professions is opening splendid opportunities before the young men of to-day, pursuits unheard of a half a generation ago. The line of success in these is closed to the 90 per cent accuracy man and the sooner our school boys and girls are made aware of this fact the better for them. No! after methods are understood only correct work should be countenanced.

The other day I had an occasion to give a final examination in elementary algebra. Among the questions was one involving the solution of a system of simultaneous equations, another in-

volving the evaluation of a determinant, another the evaluation of a fraction involving radical expressions. A student whose paper showed that he understood the theory did not get correct results in any of these questions. His mark was zero and he was told that he could get no credit until he was able to get results. He is a student who aspires to the engineering profession. How long would such a blunderer last in such a profession? Last fall a pupil entered my class in beginning algebra with a report from his grammar school which showed a grade of 95 in arithmetic and yet that boy could not multiply or divide decimals and common fractions and get a correct result, and his father could not understand why he failed in his algebra work.

Another contributary cause to the inaccurate character of the products we turn out is the large number of subjects which we feel called upon to teach. I have not time to discuss this point more than to insist that we ought to teach less in quantity but more in the quality of work required. I will recur to this matter later.

Closely allied to accuracy is a common sense use of mathematics. Said Professor Woodworth at a recent meeting of electrical engineers, "The thing we want to get hold of most is good common sense mathematics." May I give a case or two in point? Last fall I gave to the class in algebra circular discs of cardboard. The diameter was to be measured with a foot rule divided to tenths of inches, estimating the nearest hundredth of an inch, and the circumference calculated.

Here is a sample of the work handed in with a perfectly straight face:

$$
\begin{array}{r}
3.1416 \\
6.65 \\
\hline
157080 \\
188496 \\
188496 \\
\hline
20.891640
\end{array}
$$

The boy had simply used his figures in a mechanical way with no thought as to their meaning. Not a single member of the class could see anything absurd about the results. It took a long

time to convince them of two things. First, that the third figure of the measurement was doubtful. Second, that that should be taken into account in the calculation. By the device of coloring the doubtful figures this was at last accomplished:

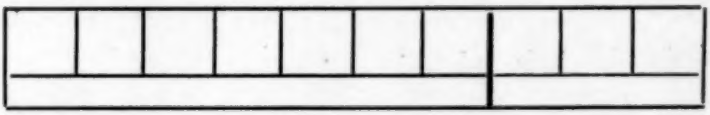
In another exercise of similar character this result was presented. $.03\frac{341}{440}$

Students of our school mathematics get hold of the idea that the results of mathematical work must be exact and should be carried out to a large number of decimal places. They are therefore led into the mistake of thinking that exact results can be gotten from inexact data. And so when they have to apply their methods of calculation to the real work of mathematics they perform a large amount of useless and valueless work. But not only does this waste of time and effort follow but more fundamental errors arise. A few summers ago a mathematical professor in one of our leading universities founded a theory on the difference between two units in the tenth decimal place in a series of calculations performed upon five figured data. Another university professor sent back a thesis to be revised because the last figure in a result obtained from a long series of logarithmic calculations did not agree with his own result calculated by another method, when the figures concerned were clear beyond the possible accuracy of the tables used. Such use of figures is entirely unwarrantable and the results are absolutely worthless.

Almost no attention is paid to this important matter in our texts. True a shortened multiplication or division method is often given. But its use is seldom pointed out. The first time a student is brought up face to face with the question is in the physics laboratory. He has been taught that figures are sacred to the last one of a long string and he therefore cannot understand the use made of mathematics in physics. He either goes through a mass of useless and meaningless work or else becoming disgusted with the seeming inexactness of physical calculations becomes careless, thinks that any result will do. Of course it is now devolves upon the physics teacher to correct his mathematical ideas and make them usable. This, I say is a task which should not be put upon him. The pupil should have been taught common sense mathematics in the first place.

Of course one reason for the present condition is this that the pupil is not brought into intimate contact with real problems in which mathematics is required. In a division of twenty-five just

entering our first year work there were but two who could measure a rectangula block of wood to tenths of inches and compute the volume. Not a single one could cut a strip of cardboard so that it should have a given area. A strip 1½ by 10 inches was given. It was required to cut a strip of area 12 square inches and this was the way it was attempted:



Only ten could be cut off.

Our texts aoound in scholastic, academic problems that are artificial and unnatural. Here is one taken from one of the best arithmetics with which I am acquainted.

"What is the radius of a circle whose area is 153.9384 square rods?" The answer is exact, of course, using the value of π given in the example at the top of the page. How often do I hear this remark from pupils: "But that answer cannot be correct because it does not come out even." Deliver me from this peptonized pabulum which is fed out to students as mathematics. Most of our popular texts on trigonometry are quite humorous in the seriousness with which they compute angles to the tenth of a second when the measured sides are given in three figures and the angles read but to minutes. A problem had better be left out if it cannot be given in a rational, sensible, real way. For, and I wish to repeat this, the intrepretation of mathematical formulæ and the ability to express relations in mathematical form is the essense of mathematical training.

A common sense use of figures in calculation should be taught early. By no means does this imply that a careful consideration of the theory of errors be attempted, for that would be impossible; but certain modes of procedure should be given and their reasonableness and inevitability enforced by suitable illustration. The impossibility of exact physical measurement should be revealed. I say revealed, for it is a revelation to the student.

A rectangular block of wood or metal in the hands of each pupil will furnish the material. Let him make the measurements himself and compute the volume.

First say to inches $3\times2\times2=12$. Use inch scale.

Next to tenths of an inch $2.7\times2.0\times2.2=11.88$. Use scale divided to tenths.

Then to hundredths of an inch $2.67 \times 2.01 \times 2.18 = 11.699406$. Use scale divided to hundredths.

It may be then stated that the teacher has measured more accurately by use of a comparator with the result $2.673 \times 2.002 \times 2.181 = 11.671285626$.

Mark doubtful figures in red.

The student now sees the force in the practical rule; calculated results should show no more significant figures than the measured data. He sees or rather feels the need of a way of getting rid of so much useless calculation and the common method of contracted multiplication is evolved

There should also be discussion of the closeness of approximation to be used in various circumstances. Measurement of farm areas and lengths, city lines and lots; the measurement of the carpenter and the machinist; the county surveyor and the U. S. Geodetic survey.

If our problems were more intimately connected with actual work we would have fewer pupils like one in our entering class who was puzzled over what to do with the 4 in this problem: One of the largest trees in Illinois is a cypress in Pulaski County. It was found to be 21.6 ft. in girth, 4 feet above the ground. What is its diameter?

All this work can be done in arithmetic and is decidedly more mathematical than the division of

60 gal. 1 pt. by 4 gal. 2 qt. 1 pt.

taken from the same arithmetic mentioned a few moments ago

Elementary mathematics without a common sense interpretation of results is mathematics gone mad. Mathematics should be taught as it is used. Instruction in it should keep pace with the practice of those who daily use it in the serious work of the world. It must then be common sense and reasonable.

(To be continued)

There is a shortage of teachers in the various school districts in eastern Washington, some of the counties having places for as many as thirty competent teachers. This shortage also appears in northern Idaho and eastern Oregon, where new schoolhouses are being opened.

The high school at Rosalia, which ranks as one of the finest school structures in eastern Washington, has been opened with a large enrollment. The teaching force is limited, but will be enlarged as soon as teachers can be obtained by H. N. Showalter, county superintendent. E. A. Bryan, president of the state college, was one of the speakers. The structure cost $25,000.

A CLASS OF CONTENT-PROBLEMS FOR HIGH SCHOOL ALGEBRA.*

G. W. MEYERS,
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Some fifteen years ago the doctrine of correlation was just beginning in the elementary school. Practical teachers in the grades then looked upon the advocates of the doctrine as faddists, or *visionaires*. First attempts to practice the doctrine were half-hearted, sporadic, and poorly planned. But the great influx of new material was threatening to submerge and to disrupt elementary-school curricula. School administrators felt that something must be done to avert disaster, and the most advanced of them began urging upon teachers the imperative need of studying into the larger unities of the rich supply of materials that had accumulated. Slowly the teachers took up the work. The first efforts to correlate the raw materials of education around a central idea were feeble, and but little better than travesties on the idea. School work became spotted. One idea was well—even brilliantly—worked out with the class; then there was rambling, time-filling, and wool-gathering. The new attempts became the target of sharp criticism, then of keen ridicule. But, by those who tested the doctrine, the brilliant spots were felt to be better than a dead level of stale insipidity. The patient maturing of the practical phases of the doctrine, and a fuller trying-out under the light of past failures, have at length secured the general, though sometimes tacit, adoption of the doctrine of correlation in all the leading elementary schools of our country. Nowadays every new subject that knocks for admission into the elementary school, no less than every one of the old pre-emptors of the ground, must justify its claims on grounds of its bearings on the all-round work of the school. All of these matters may serve well for enlightenment and encouragement in the struggle with intrenched tradition and buttressed conservatism in the secondary school.

As the field of battle for better teaching shifts from the elementary

* From School Review.

to the secondary domain, it is only natural that the leaders of the reform should resort to the same line of tactics that has proved successful in the field already taken. Accordingly, the doctrines of correlation are recommended to secondary teachers who are seeking improvement. The danger which is always present at this point is that the recommendation will be construed to mean the same phase of correlation as has wrought the improvement in elementary teaching. But it will hardly be expected that the same breadth of correlation where *extensive* study is the characteristic feature of the pupil's effort can be successfully attempted where *intensive* work is wanted from the student, as is the case in the secondary school.

The law that what is best for the adult is not necessarily best for the child, which has protected elementary programs from the *ex cathedra* utterances of college teachers, may well be stated now and then the other way around. This shifts the emphasis and materially alters the meaning. What is best for the child is not necessarily best for adults. As an illustraton, it may be cited that, while an adult can very profitably work under a *remote motive*, a child needs an immediate motive to draw forth his best effort. But the change from the mental traits of childhood to those of adulthood is a growth. No one can put his finger on any stage of the school career and say *here* is an abrupt break in continuity of growth. By the beginning of the high-school period, however, there has been a very considerable accumulation of modifications, and the significant question for the practical high-school man is: What do these changes mean as to the necessary modifications of, or deviations from, elementary-school procedure? Programs of study, textbooks, and discussions all seem to pre-suppose only *difference* of procedure. However unphilosophical this consensus may be, it can nevertheless be explained, if not justified, historically. The vital question is: How much of likeness and how much of difference should characterize elementary and secondary work? It is this unanswered question which makes the chief trouble for mathematics.

It has been customary of late to argue and to work for an all-embracing correlation of early high-school mathematics with science and with the quantitative phase of the pupil's life. This sort of correlation, though ideal, is very seriously hampered both by the

present order of science subjects in the curriculum and by the extreme difficulty of so organizing the pupil's out-of-school interests as to accomplish the ends of mathematical study. The difficulty just mentioned is, nevertheless, being attacked, and progress is being made in overcoming it; but progress in this direction is necessarily slow.

Some have narrowed the problem of correlation down to a unification of *mathematics* and *physics* in teaching. But even this phase of the problem of securing a continuity and homogeneity to the pupil's school life, commendable as it is, is hampered both by the present arrangement of subjects in the program and by the difficulty of procuring teachers that are able to handle well both physics and mathematics. In the May number of this journal Mr. Moore narrows the problem of correlation still more closely. As a first stage in progress toward a full-orbed correlation of all cognate quantitive concerns of the pupil, his suggestion is to correlate, or to unify, the *mathematical subjects* into a homogeneous body of truth through the extensive and continuous use of the cross-ruled paper. This plan is eminently practicable. Programs need not be disturbed outside the mathematical subjects, and these disturbances may readily be taken care of by mathematical teachers themselves. There can be no objection to the proposal on grounds of expense, for cross-lined paper can be had at a cost so nominal that pupils themselves can bear the burden. From the numerous and varied uses of the graph that Mr. Moore suggests, it would seem that everyone who desires to assist in improving teaching—and who does not?—could readily find a place to lay hold at once. The paper points out in detail how any analytical operation a high-school pupil is ordinarily called upon to make, as well as many other operations that are too complicated for him analytically, may be simply and vividly put before him graphically by the aid of the cross-ruled paper. If this graphical work be now put into some sort of organic relationship with real problem-work—work that seems real to the pupil—that best of all results of teaching will in good degree be secured, viz., an interest in and love for mathematical thinking. As teachers of mathematics we need to keep continually before our minds the fact that the highest of all educational aims

is neither *learning* nor the mere *power to acquire learning*, but a *real love to learn*. Interest and purpose are necessary to the attainment of this aim in mathematical study.

It is the demand of the hour for high-school mathematics, and is the spirit of Mr. Moore's paper, that some means must be found of enabling the pupil, as early and as continuously as possible, to realize the worth to him of his mathematical tasks. The problem of arousing and sustaining interest will then be solved. The work must have such content and treatment as to place and keep the pupil where, by his own standards of worth, he may both gauge and approve the merit of what he is required to do. It is not the intention even remotely to imply by the foregoing statement that the teacher is to ask the pupil whether the latter thinks a proposed task is worth while. What is intended is that the nature of the tasks put before the learner shall be such that, no matter how great their difficulty, there will be a steady undertone of assent on the part of the learner that the tasks are worth the effort. This is recognized as essential in other subjects. It must be so recognized in mathematics before its full educational value can be realized.

Youth of the early high-school period are profoundly impressed with "the *go*" and "the *do*" of things. They feel that they have added a cubit to their mental stature when they have learned a new truth about the way man and nature accomplish results. The number of young persons on the bleachers at a high-school game, who are enthusiasts in convincing listeners that they know how to do it is out of all proportion to the number who can actually do it. Some have criticized our school system as a producer of "lip-doers" rather than actual doers. Be this as it may, the normal youth of fourteen to sixteen, or seventeen, loves to learn how the forces of nature are made to do the work of man and of nature. A machine is of interest to him, not as a machine, but because it does something. A large number of our simple machines, utensils, and our commonest apparatus are based upon the laws of parallel forces, and, with very little time and almost no technical introduction, numerous problems, covering a wide range of algebraic theory and technique, might be used to enrich the content of early algebra with conceptional material that makes a general appeal to youth. It is the main purpose of

this paper to show how easy and practicable it is for mathematical teachers to levy tribute from this field.

Two simple principles, or laws, will be needed, and it will be shown here how, in three forty-five minute recitation periods first-year pupils were given a working hold on these laws.

A light, wooden bar, as *ss* in the accompanying figure, was so arranged that it might move easily upward or downward, but could not turn around, when upward and downward forces were applied to it at the pegs, along the bar.[1] Two pegs, one at the middle of the bar and the other a little below it at I, work easily within a slot and prevent the bar from turning. The balls at *s* and *s* could be screwed inward or outward to balance the *unloaded* bar horizontally. Weight enough was then placed at *D* to hold the empty bar suspended. After the balances were adjusted, the class was told to pay no further attention to the weights at *D* and at *ss*. These were merely a part of a device for getting a *weightless bar* (or it may be called a *beam*) that may move easily upward, or downward, without turning.[2]

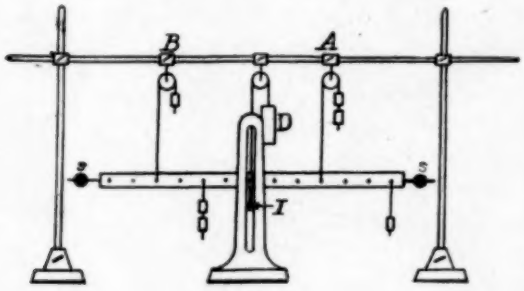


FIG. 1

Light weights could then be hooked on any of the pegs, and, by pulleys, such as those at *A* and *B* in the figure, forces pulling

[1] In this connection compare an article entitled "Algebra Evolved from the Learner's Experience," by Arthur C. Lunn, in *Mathematical Supplement of School Science*, April, 1903; also, "An Algebraic Balance," by E. C. Donecker, in *School Science and Mathematics*, June, 1905; also, "Another Algebraic Balance," by N. J. Lennes, *ibid.*, November, 1905.

[2] The bar and weights used in the apparatus of this paper are parts of an apparatus for experimenting with forces, designated "Mechanical Powers, No. 382," p. 37, of the *Catalogue* of C. H. Stoelting & Co., 31–45 West Randolph street, Chicago, for 1901. With these pieces the work of fitting up the apparatus is almost nothing at all. With only a little more trouble one may provide himself with a home-made device that is good enough. Spools will answer for pulleys.

upward could also be applied at any of the pegs. Any number of pulleys could be quickly hooked over the rod AB. The pegs were equally spaced, and the individual weights were all equal. (Small cans, loaded equally with sand, will answer.) The weight of each was called w or x. Weights pulling upward were written and called positive; those pulling downward, negative.

The class was asked, for each loading, to begin on the left, and to record the circumstances of each loading in the form of an algebraic expression, and to show the value of each expression by an equation. In this expression each force entered as a monomial term with its appropriate sign. For example, with the loading shown in the foregoing cut, the class wrote in their notebooks the following record:

Equation	Result
$+x-2x+2x-x=0$	No movement

For other loadings, the records were as follows:

Equation	Result
$+3x-x-x-x=0$, ...	No movement
$+2x-3x+2x-2x=-x$	Movement downward
$-4x+2x-2x+5x=+x$	Movement upward
etc.	etc.

A half-dozen to a dozen such records were made, and the "Result" was obtained by noticing the behavior of the bar.

Pupils were next asked to examine their records to see whether, for imaginary loadings, they could tell from the equation what the bar would do. The class was then given such expressions as $+5x-3x+2x-x$; $+4x-x+3x-4x-2x$; etc. Many made correct predictions and records, and the rest soon "caught the scheme." When there was trouble, the apparatus was resorted to.

Pupils were then asked to state what the value of the algebraic sums of all the forces acting on the bar must be *for balance.* With little difficulty, the substance of the following statement was brought out and accepted as the first law for parallel forces:

LAW I: *For balance, the algebraic sum of all the forces acting on a bar, or beam, is equal to zero.*

Beginning at the first peg to the right of the center, the pegs on the right were designated r_1, r_2, r_3, r_4, r_5, and r_6; and those on the

left, l_1, l_2, l_3, l_4, l_5, l_6. Problems were now given of the following types:

With 2 weights, x, at l_3, 1 weight, x, at l_2, 1 weight, x, at r_2, 2 weights, x, at r_3, and an upward force $6x$, at r, write the "record" and the "result." Also give the record and result, if the upward force of $6x$ is replaced by an upward force of $5x$, other weights remaining as above; also, if the $5x$ is replaced by an upward force of $7x$.

Write the appropriate equations and the results, that would be shown by the beam, for the loadings represented by the numbers in each horizontal line of the following table:

Peg.....	l_6	l_5	l_4	l_3	l_2	l_1	r_1	r_2	r_3	r_4	r_5	r_6
No.												
1.....	$+x$	$+x$	$+x$	$-3x$	$+x$	$-x$	$-x$	$-3x$	$+x$	$+x$	$+x$	$+x$
2.....	$-x$	$-x$	$-x$	0	0	$-4x$	$+4x$	$-2x$	$+x$	$-2x$	$-x$	$-x$
3.....	$-w$	$+3w$ etc.	$-w$	0	0	0	0	0	0 et..	$-2w$	$+w$	$+w$

Enough of this problem-work was done to make pupils able to use the law easily, to give some ease in adding such monomials as occur in the problems, and to impress pupils with the idea that an equation means the expression of a condition; i. e., it is a record of *what the bar shows by balancing.*

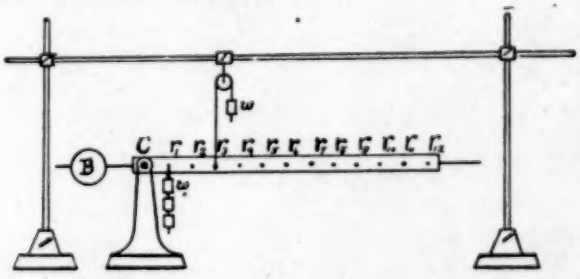


FIG. 2

To obtain a working notion of the second law, the first necessity was to give pupils a mathematical notion of *leverage*, or *turning tendency* (these terms were preferred to the word *moment*). An apparatus like that shown in the adjoining cut was used to give mathematical precision to the notion, after citing the force and leverage required to turn a grindstone, to turn belted pulleys, etc. Here the bar is so arranged that it can turn, but cannot move upward

or downward as a whole, i. e., *in translation*. The bar was balanced empty by the aid of the ball *B*. A weight, x, being at r_1 was seen to turn the right end of the bar downward; while a weight x, pulling upward at r_1 by aid of the pulley, turned the right end upward. Here were two kinds of turning motion, which needed to be distinguished. The kind of turning which the positive force produced, i. e. *anti-clockwise*, was called *positive*, and the opposite kind, i. e., the *clockwise*, was called *negative*. The problem was now to measure and express these *turning tendencies*, or *leverages*, as numbers. The pulley was placed above the peg r_1, and loaded with one weight, w, and weight enough was hung to the peg r_2 to prevent turning. Then the pulley was slipped to the right so that an upward force of w acted on the peg r_2, and enough weights ($2w$) were hung to peg r_1 to prevent turning. The pulley was then slipped along so that an upward force of w could be applied successively to r_3, to r_4, to r_5, etc., and in each case weights enough were hung to r_1 to prevent turning. Calling the distances between the pegs 1 (unity), it was soon found that the number of weights on r_1 was always equal to the product of the number of weights on the pulley-cord by the number of units in the distance from *C* to the peg where the upward force was applied to the bar. Since the bar balanced only when the *positive turning tendency* of the upward force was just equal to the *negative turning tendency* of the downward force, it was clear that the number of weights on peg r_1 *measured the turning tendency* of the upward (positive)force. The distance from *C* to the peg, where any one of the forces, upward or downward, was attached to the bar, was now named the *arm of the force*, and the *turning tendency, or leverage*, of any force was defined *to be the product of number* of units in the force *by the length of its arm*. The class was now told to call the distance between any two adjacent pegs x, and to express all arms in terms of x. Records were then made as was done in deriving Law I. For the loading shown in the cut the record was:

Equation	Result
$(-3w)(x)+(+w)(3x)^*=0$	No turning

* The +'s between the several products were read "and." Thus "minus $3w$ times x and plus w times $3x=-3wx+3wx=0$."

Looking at the bar, the class saw that the first force had a *negative*, and the second a *positive*, turning tendency. Hence, $(-3w)(x)+(+w)(3x)=-3wx+3wx=0$.

Other records with two, or more, forces were as follows:

	Equation	Result
(1)	$(+3w)(2x)+(-2w)(3x)=$ $+6wx-6wx=0$	No turning
(2)	$(-4w)(2x)+(+w)(2x)+(+2w)(3x)=$ $-8wx+2wx+6wx=0$	No turning
(3)	$(-3w)(2x)+(+w)(2x)+(+2w)(3x)=$ $-6wx+2wx+6wx=+2wx$ . .	Positive turning
(4)	$(-5w)(2x)+(+w)(2x)+(2w)(3x)=$ $-10wx+2wx+6wx=-2wx$ . .	Negative turning
	etc.	etc.

Enough loadings were given to make the pupils sure of their interpretations of signs and turning tendencies. By examining a dozen such records as the above, the fact was soon brought out that for balance of this bar, the algebraic sum of the turning tendencies of all the forces must be equal to zero. This form of the apparatus was then changed for that shown in the following cut.

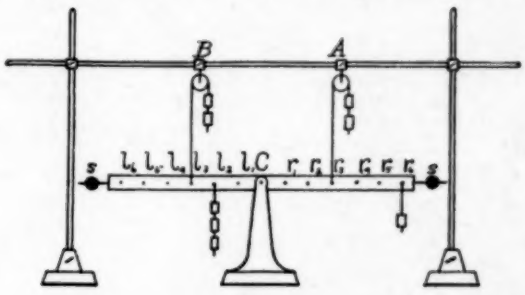


FIG. 3

For this new form of apparatus the following agreements were made and recorded on the blackboard and in the notebooks:

1. *Forces pulling upward on the bar shall be called positive, and written +; those pulling downward, negative, and written −.*

2. *Arms measured from C toward the right shall be called positive; toward the left, negative.*

3 *Turning tendencies anti-clockwise shall be called positive; clockwise, negative.*

It is well worth while to give more extended use of the laws of signs in sums and products of signed numbers, than is customary.

A number of loadings were then given and the circumstances recorded thus:

	Equation	Result
(1)	$(+2w)(-3x)+(-3w)(-2x)+(+2w)(+3x)+(-w)(+6x)=-6wx+6wx+6wx-6wx=0$.	No turning
(2)	$(+2w)(-3x)+(-3w)(-2x)+(+w)(+3x)+(-w)(+6x)=-6wx+6wx+3wx-6wx=-3wx$	Negative turning
(3)	$(+w)(-5x)+(-2w)(-3x)+(+3w)(+2x)+(-w)(+6x)=-5wx+6wx+6wx-6wx=+wx$	Positive turning
(4)	$(+2w)(-6x)+(-w)(-2x)+(-w)(-x)+(+4w)(+3x)=-12wx+2wx+wx+12wx=+3wx$	Positive turning
(5)	$(+2w)(-5x)+(+w)(-2x)+(+4w)(+x)+(+4w)(+2x)=-10wx-2wx+4wx+8wx=0$.	No turning
	etc.	etc.

A number of imaginary loadings were now given, and the class was asked to make records from the equations without reference to the bar. It was soon apparent that everything could be obtained directly from the equation and that the apparatus was no longer necessary. The *second law* of parallel forces was easily derived from an examination of the records, and was stated and written in the notebooks and on the board:

Law II. For balance, the algebraic sum of all turning tendencies must equal zero.

From here on the class was required to take on faith the generalization that, if any sort of bar, beam, or body whatsoever is in equilibrium—i. e., is lying still—under the action of parallel forces, the two laws just derived always hold good.

It was thought well to convince the class that the arms need not be measured always from the middle of the bar, or body; but that they may be measured from *any convenient point along the bar*, and, in particular, from either end. The only requirement was shown to be that, once a point (called the *turning-point*) has been selected to measure arms from, all arms throughout any problem must be measured from this same point. Some of the loadings and exer-

cises given above were solved by taking the turning-point, real or assumed, at some side peg, or at an end peg. The results always agreed with the previous solutions, though the forms of the equations differed with the choice of the turning-point. This is an advantage for teaching, as by a suitable choice of the turning-point the teacher may obtain the form of equation he desires.

By the aid of the two laws of force and of the four axioms of addition, of subtraction, of multiplication, and of division, a variety of practical problems, such as the following, were solved. It seemed well to enhance the pupil's confidence in the utility of the laws by giving first some problems so simple that the pupil could know the result from the outset, and to rise gradually to more difficult problems, whose results could not be foreseen.

SAMPLES OF PROBLEMS AND TYPES OF EQUATIONS THEY CALL FOR

1. A basket, weighing 84 lb., hangs on a stick 6 ft. long at a point $1\frac{1}{2}$ ft. from the end, while it is being carried by two boys, one at each end of the stick. How much does each boy lift?

Taking the turning-point at the middle of the stick, and denoting the weight borne by the boy carrying the short end by x, and that borne by the other boy by y, we write from Law I, $x+y-84=0$, giving $x+y=84$; and from Law II, $(+x)(-3)+(-84)(-1\frac{1}{2})+(+y)(+3)=0$, giving $-3x+3y=-126$.

The solution of the reduced forms calls for standard algebraic methods.

2. Solve a problem like 1, supposing the basket to weigh 60 lb., and to hang at a point 1 ft. from the end of a 4 ft. stick; 2 ft. from the end; 3 ft. from the end.

Taking the turning-point at the middle and denoting the forces as before, the reduced forms of the required equations are:

(1) $\begin{cases} x+y=60 \\ 2x-2y=60 \end{cases}$ (2) $\begin{cases} x+y=60 \\ 2x-2y=0 \end{cases}$ (3) $\begin{cases} x+y=60 \\ 2x-2y=-60 \end{cases}$

All these are familiar enough as types of linear, simultaneous equations.

3. Two men lifting, one at each end of a stick 8 ft. long, raise a certain weight. How heavy is the weight, and at what point does it hang, if one man lifts 25 lb. and the other 75 lb.?

Solution: From Law I, $+25-w+75=0$, whence $w=100$ lb. Taking the turning-point at the middle of the stick: From Law II $(+25)(-4)+(-w)(-x)+(+75)(+4)=0$ ($-x$ being the arm of the weight); whence $wx=-300+100=-200$. Since $w=100$, $x=-2$. Interpret the result by a sketch.

4. Suppose a bar 10 ft. long, weighing 30 lb., to be used by two men, one grasping it at each end, to carry a load of 170 lb. How many pounds must each man carry, if the load hangs from a point 2 ft. from the front end?

NOTE—The weight, 30 lb., of the bar itself may be treated as a load of 30 lb. hanging to the bar at its middle point.

Solution: Taking the turning-point at the middle of the bar, we have from Law I: $+x-170-30+y=0$, whence $x+y=200$; Law II: $-5x+510-0+5y=0$, whence $-5x+5y=-510$, or $-x+y=-102$.

REMARK.—The zero-term in the second equation arises from the leverage of the weight of the bar, which is 30×0. Here is a chance for a concrete interpretation and an algebraic treatment of the product of *any number multiplied by zero*.

5. A stone slab, weighing 2400 lb., rests with its edge on a crow-bar 6 ft. long, at a point 6 in. from the end which is used as the fulcrum. How many pounds of force must a man lifting at the other end of the bar exert just to raise the stone, (1) omitting the weight of the bar itself? (2) if the bar itself weighs 40 lb.?

Solution of (1): From Law I: $+F-2400+x=0$; or, $F+x=2400$. From Law II: $-3F+6000+3x=0$; or, $-3F+3x=-6000$, (turning-point at middle of bar).

Since the pressure of the support at the fulcrum is usually not wanted, we might take the turning-point *at the fulcrum-end*, whereupon Law II would give: $(+F)\ (0)+(-2400)\ (+\frac{1}{2})+(+x)(+6)=0$; or, $6x-1200=0$, whence $x=200$ lb.

REMARK.—This gives another actual practical use of the product of a finite number multiplied by zero. It is also clear that a teacher may adapt the problem to exemplify either the one or the two-unknown mode of solution.

6. Three boys desire to carry a 12-ft. log, weighing 240 lb. Two of the boys lift at the ends of a hand-spike placed cross-wise underneath the log, and the third boy carries the rear end of the log. Where must the hand-spike be placed that all may lift equally?

Solution: Taking the front end of the log as a turning-point, and calling x the distance from the turning-point to the spike, we have from Law I: $2f-240+f=0$; and from Law II: $(+2f)(+x)+(-240)(+6)+(+f)(+12)=0$. From these equations we have: $3f=240$, or $f=80$, and $2fx+12f=1440$. Substituting f, we find $x=3$ ft. Interpret the result.

NOTE.—This is an easy case of algebraic problem in three unknowns. The form of the problem may be modified almost at the pleasure of the teacher, by taking the turning-point at other places along the log.

It is interesting gradually to generalize the foregoing problem by supposing, first, that the length of the log is 6 ft., and the weight 240 lb.; then, that the length is 6 ft, and the weight x lb., the number of boys still being three; and, finally, that the length is 6 ft., the weight is w lb., and the number of boys lifting at the spike is $2n$ (n at either end of the spike, making in all, $2n+1$ boys).

We shall omit the solutions of the following, but they will be found to involve interesting and varied algebraic forms.

7. A steel beam 24 ft. long, and weighing 120 lb. per yard, is being moved by an axle, borne by a pair of wheels placed under it at a point x ft. back of the front end and y ft. in front of the middle point. The rear end is being carried. If the weight carried at the rear end is 200 lb., what must be the values of x and y and of the weight, w, on the axle just to move the beam?

8. How may a railroad rail weighing more than a ton be weighed with a spring balance running only up to 50 pounds?

9. A wheelbarrow is loaded with 45 bricks weighing 6 lb. each. What lifting-force will be needed at the handles just to raise the load, if the hand is $4\frac{1}{2}$ ft. and the center line of the load is 2 ft. back of the center of the wheel?

10. The box of a push-cart is 5 ft. long, and, when full, it holds 660 lb. of earth. The axle is $1\frac{1}{2}$ ft., and the handle-bar is 7 ft., back of the front end of the box. When loaded with earth, what lifting-force at the handle-bar will just raise the legs from the ground, and what will then be the weight on the axle?

11. If the legs of the push-cart of problem 10 are just under the rear end of the box, what will be the weight on them, and what the weight on the axle, if the cart is standing still on level ground, and loaded with earth?

12. The handle of a suction-pump works against a pin 2 in. from the point where the plunger is attached to it, and the hand seizes the handle

3 ft. from the same point. What lifting-force will be exerted on the plunger, and what will be the pressure on the pin by a downward thrust of 20 lb. at the hand; this being just force enough to work the pump?

13. The arms of a balance are x and y. When a mass w is placed in one scale-pan, 16 lb. placed in the other pan will just balance it. When the mass, w, is placed in the other pan, only 9 lb. are needed to balance it. What is the correct weight of w? What are the lengths of the arms?

Solution: Law II gives $(-w)(-x)+(+F)(0)+(-16)(+6)=0$, or $wx=16y$, for the first weighing; Law II gives $(-9)(-x)+(+F)(0)+(+w)(+y)=0$, or $9x=wy$, for the second weighing.

Dividing, we readily find $w=\pm\sqrt{144}=\pm 12$. Interpret the double sign. Here algebra shows itself liberal and provides for the possibility that the weights may pull either *upward or downward.*

Taking other values instead of the 9 and 16, as 10 and 12, we have a practical problem for the introduction to the study of radicals, for we should then have $w=\pm\sqrt{120}$

Multiplying the equations, we readily find $\frac{x^2}{y^2}=\frac{16}{9}$, whence $\frac{x}{y}=\pm\frac{4}{3}$ Interpret. Can the plus sign have meaning here? If 10 lb. and 12 lb. were used, we should have $\frac{x}{y}=\sqrt{\frac{10}{12}}$, and again there is a call for radicals.

Common road wagons, carriages, automobiles, floor-joists, bridge-girders, roof-trusses, etc., furnish an abundance of conditions calling for simultaneous equations. The reply that such problems call for much technical knowledge is untenable. Only the two laws already given are needed. Space permits only a few more examples to illustrate how this work may be given a formal turn.

14. A floor-joist lies at rest under the three parallel forces $+x$, $+y$, and -5, whose arms are, $+3$, -2, and $+1$, respectively. Find the strength of the unknown forces x and y.

15. A bridge-girder is at rest under the action of the forces $+x$, -10, $+y$, and -2, with arms, respectively, -4, $+2$, $+5$, and $+11$. Find x and y.

When quadratics are wanted, such problems as this will answer:

16. A roof-truss lies at rest under the forces $+x$, $+y$, and -2, with arms $+x$, $-y$, and $+8$. Find the values of x and y.

The equations here needed are $x+y=2$, and $x^2-y^2=16$. Such equations will not be denied an algebraic value, even by the ultra-formalist.

From now on formal problems of any of the customary algebraic types of linear, or linear and quadratic, simultaneous equations may be taken up with understanding on the pupil's part. The work will be backed up with a feeling on the part of the learner that such problems are called for by matters that have a modern meaning and a real use, at least; and this much cannot be said to the credit of the work which the high-school pupil of algebra is commonly called upon to do. High-school pupils work much better under a *mixed* than under a *pure* faith in the ultimate usefulness of what they are required to do.

Almost everyone of the foregoing equations might profitably be given a graphical treatment. It was the purpose of this paper to show at least one rich and easily accessible field to draw upon for material to vitalize and to conceptualize the equations and functions that Mr. Moore would treat very extensively by the aid of cross-ruled paper. It is believed that enough has already been given to accomplish this purpose. If there are those who still doubt the value of such work as is here advocated, let them allow their doubts and skepticism to be dissipated by the test of practical trial!

EARTHQUAKES IN PERU.

In 1647 within a space of two and a half months there were 120 earthquake shocks in Peru, in one of which the city of Santiago was devastated and more than a thousand persons killed.

On October 28, 1746, in the city of Lima, 10,000 persons perished from an earthquake shock, and during the 112 days following that date there were registered in Peru 400 distinct earthquake shocks.

In 1650 there were 226 shocks recorded between March 31 and May 20, in one of which the city of Cuzco was destroyed. It was of this city that a writer of that day said: "To live in this city is to die in the midst of many terrors and excitements."—*The Scottish Geographical Magazine.*

THE NERNST LAMP IN THE LABORATORY AND SIMPLE EXPERIMENTS ON RADIO-ACTIVITY.*

By F. R. Gorton,

Michigan State Normal College, Ypsilanti, Mich.

1. The Nernst lamp consists essentially of a specially prepared filament A, Fig. 1, called the glower, and a series resistance B, called the ballast. The glower possesses the property of conducting electricity only when hot. Joining a glower and a corresponding ballast across the electric lighting mains and heating the filament in a flame brings it into a conducting condition after which the current quickly carries it to a temperature at which it gives off an intense light. The ballast consists of an iron wire of such a length and size as to offer sufficient resistance while conducting the necessary current. Obviously the glowers and the ballasts must be adapted to the voltage on which they are to operate. These parts of the lamp already described can be had neatly mounted in lamp bodies in which the initial heating of the glower is done automatically by the current. While the complete lamps are excellent for commercial lighting purposes, a more convenient mounting is desirable for use in the laboratory. One form that has been found useful for many purposes is shown in cross-section in Fig. 2. The parts are mounted on part of a porcelain

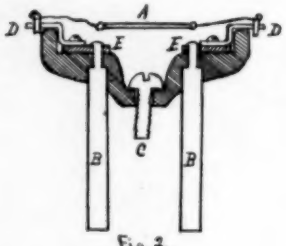


Fig. 2

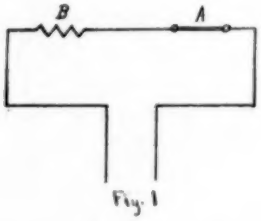


Fig. 1

ceiling rosette used in electric wiring. BB are two brass posts passing through the screw holes in the porcelain and attaching to the small brass plates EE. The joints cannot be soldered on account of the heat produced while the lamp is in operation. To the plates EE are attached the metal extensions DD. These are drilled near the outer ends to receive the small aluminum pins with which each glower is provided. The large screw C serves to connect the lamp to the kind of holder or stand desired. The

*The cuts on ratio-activity are loaned by the *Western Journal of Education*.

metal parts can be protected from the intense heat of the glower by filling the holder with plaster of Paris. The electrical connections are made by attaching flexible lamp cord to the ends of the posts BB. These contacts may be soldered. It is advisable to fit pieces of glass tubing over the posts before attaching the wires to prevent short-circuiting. The ballast may be placed anywhere in the circuit. A convenient mount is shown in Fig 3.

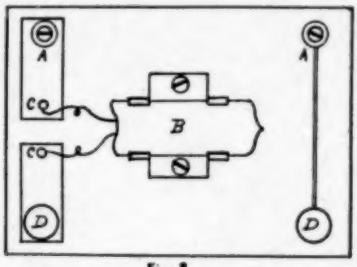


Fig. 3

The lamp as described serves admirably as a luminant for projection purposes for pictures five or six feet in diameter. Smaller pictures in a partially darkened room can be distinctly seen by a class. Two 110-volt glowers serve for projection in a room seating three or four hundred.

Another application can be made in rendering galvanometer deflections visible to a class. Place the lamp about 75 cms. in front of a mirror galvanometer and a convex lens whose principal focal length is 50 cms. about 65 cms. from the lamp and between the two. A brilliant image of the glower will be reflected upon a screen or scale placed behind the lamp at a distance of about two meters. Of course, other lenses than that mentioned may be used and the correct position of all the parts found by trial. The image is bright enough to be observed without darkening the room.

A brilliant point source for experimental purposes can be produced by placing a slit near, and at right angles to, the glower. For work in optics not requiring a very narrow slit, the glower itself serves very well.

Other uses will suggest themselves to teachers of physics as they come to use this luminant. The glowers and ballasts are made both for direct and alternating currents. They can be procured from the Nernst Lamp Co., of Pittsburg, Pa., or Chicago. The nature of the current and the voltage must be stated in ordering the parts.

2. Two effects of radio-active substances are easily made use of in the laboratory; viz., the photographic action and the electrical effect due to the radiations emitted by such bodies. Probably the most accessible substance possessing the property in any

Fig. 4. Effect obtained by placing an ordinary gas mantle upon a photographic plate. The fogging of the plate shows the presence of a radio-active substance which in this case was thorium. Time of exposure, 13 days. Lighter regions produced by interposed pieces of paper.

Fig. 5. Plate exposed 13 days to the activity of the ashes of 10 gas mantles, showing presence of radio-active substance and effect of intervening pieces of paper and thin metal strip.

marked degree is to be found in the Welsbach gas mantle. If such a mantle is laid flat against the film of an ordinary sensitive plate and left in the dark for a week or more before being removed, the process of development will bring out a distinct image of the mantle. See Figs. 4 and 5. The experiment can be made by using the mineral Pitchblende, or Uraninite, which is usually found in mineralogical collections and is kept in stock by dealers in such materials. Good results can be obtained by breaking the rock in small pieces and strewing it around upon the plate. If a coin, for example, is first placed on the plate, a clear spot will result on developing due to the shielding action of the metal. See Fig. 6. The activity of the mantle is due to the presence of

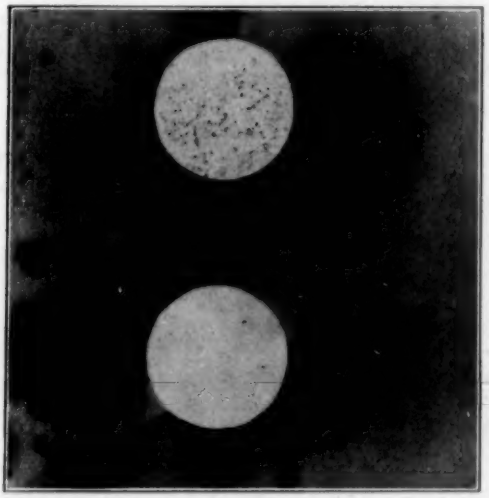


Fig. 6. Result obtained by strewing small pieces of the mineral pitchblende upon a photographic plate. The round spots show where the plate was shielded by the presence of two copper coins.

Thorium, while that of the pitchblende arises from the Uranium contained in it. A part of the activity of the latter may be due, however, to the presence of a trace of Radium which is found in pitchblende. The photographic effect may be produced by radium-cards and radium-pencils sold by dealers in such apparatus at a small price. In order to show the penetrating power of the beta-rays, plates were exposed to the action of a radium card for several days, having intervening sheets of tin-foil and paper. Figure 7 shows comparatively the shielding effect of paper and foil. Figure 8 was made by folding a sheet of tin-foil so as to

offer two, three, and four thicknesses to the rays.

The electric effect, so-called, is the action of a radio-active substance in rendering the air around it a conductor of electricity. Thus a charge placed on an electroscope will readily escape in the presence of a radio-active substance. In order to detect the influence of a radio-active body on an electroscope, we have only to make the capacity of the instrument small enough to make the loss of charge apparent. While the activity of a gas mantle can be detected, the influence of a piece of pitchblende is greater. In fact, by projecting the leaves of a small gold-leaf electroscope upon a screen, the effect of the mineral can be observed simultaneously by a number of people.

Fig. 7. Effect produced on sensitive photographic plate by a card upon which had been placed a very small quantity of radium. The light regions show the effect of intervening pieces of paper and tin foil. The paper was evidently penetrated by the rays.

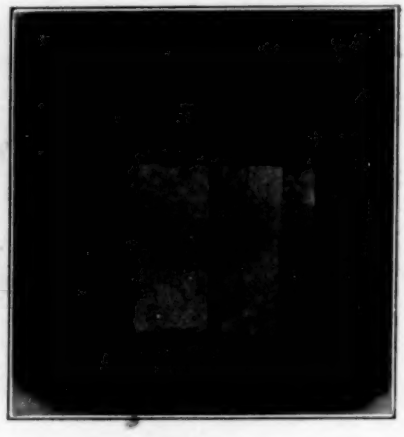


Fig. 8. Effect produced by the card used in obtaining Fig. 7. The light regions show the penetration of dfferent thicknesses of tin foil. The foil was so folded as to offer two, three, and four layers to the penetrating power of the rays.

SOME USES OF THE ALTERNATING CURRENT IN HIGH SCHOOL WORK.

By L. M. Parrott,

Saginaw High School.

I believe the alternating current may be made of almost universal application in outlining fundamental principles, and as an auxiliary apparatus it is almost indispensable.

In my own work the subject of electricity is opened by attempting to get before the pupil a clear conception of the terms used and the definite meaning of each of these terms. This naturally leads into the subject of the fundamental properties of the current, and this point, to my mind, is the basic principle upon which the entire superstructure is founded. A clear conception of these fundamental properties is therefore absolutely essential, and must be made clear and definite by actual existing evidence.

I believe we will all agree that the greatest and most important, if not *the* fundamental property is manifested by what is called, for lack of a better term, the field of force; and until the actual relation between the current and its accompanying lines of force is made unquestionably evident to the pupil's mind, all that the subject can give him will be but a hazy and imperfect idea. Experiment only can settle the question, and for this purpose a small current is not satisfactory. We are reduced therefore, in the great majority of schools at least, to the problem of either using a large number of cells, to be made by the teacher at this time, or else making use of the city's incandescent plant, which supplies an alternating current. The latter is cheap, always ready, easily manipulated, and will show many of the essential relations as completely as a direct current.

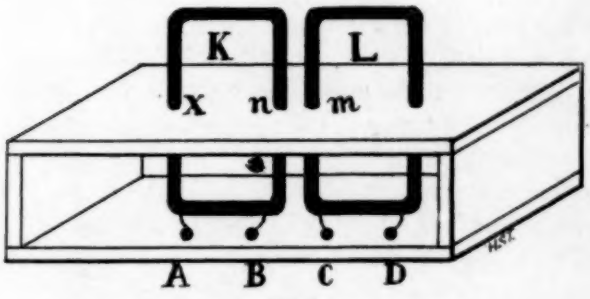
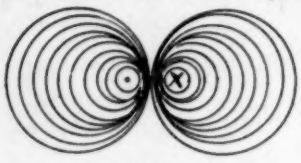
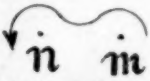
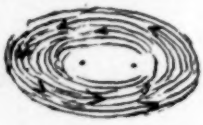


Fig. 1.

To illustrate: If we connect the terminals of the alternating current, through a suitable rheostat, to the posts A and B (Fig. 1) respectively, so that it surges back and forth through the coil K, and sprinkle iron filings around the point x the circular lines of force will be evident, thus showing the existence of a field of stress of some nature encircling the current-carrying wire. These lines of stress, however, may be more than mere circles of force, and are possibly endowed with some kind of a direction property as well, or possess what might be termed a head and tail with the heads all turned one way with reference to the direction of the current. This question may also be clearly demonstrated by means of our alternating current.

Assume, if you will, that this stress about the wire, or so called field of force *is* endowed with a direction property; then if we assume a particular direction in which the lines are all headed with reference to the direction of the current, for example, as indicated; and now arrange two parallel wires with current flowing in opposite directions, by connecting the terminals at A and D, and an extra wire from B to C, so that the current flows through both coils represented in Fig. 1, the combined field would necessarily be something like this:  With a thick and highly strained field between the two wires. Now, still supposing this same direction property, if we exchange the terminals A and B, thus reversing the current in one of the coils, we will have it passing through the two central wires, parallel, and in the same direction. 

Under this condition a line of force circling around the wire m would, when attempting to exert its force, or as some would say, when attempting to pass, between the wires, come under the influence of the current in wire n, and thus be prevented from exerting itself in the space between the wires, and, affected by this influence, must continue on around the wire n, and so enclose both wires, presenting a field like this: 

Connecting up respectively in the two ways indicated, we see the fields are so arranged. This effect must therefote be due to the cause indicated, and

we are inevitably compelled to accept the fact that all lines of force do possess a direction property of some nature. That is, when the current goes one direction, the lines of force also have a direction property, dependent on the current direction. Assuming a head and tail for each line, we mean the heads are all turned one direction around the wire. Which direction we call head, or which tail depends only on convention, and convention has established that the arrow head in the ffgure is to be called head, or, as ofttimes falsely stated, the line passes around the wire in the direction indicated, the dot meaning current coming up out of the paper.

Some additional facts may be deduced from the two fields represented (Figs. 2 and 3).

Turning our attention to these figures and remembering that these lines are a stress or strain around the current-carrying wire, and should therefore act like stretched elastic bands, we note certain actions likely to result. In Fig. 2 these lines are crowded and need more room. Therefore, by their very nature, they should press these wires apart.

On the other hand, the situation as exemplified in Fig. 3 should be such as to cause the wires to be drawn together.

These facts may be illustrated by means of two coils set up as indicated, the alternating current being fully as effective in proving these well known laws as a direct one.

This simple apparatus may be briefly described as follows: *A* and *B* are two coils in series, *A* stationary, and *B* supported by a central axis *mn* upon which it may freely turn, its ends dipping into the respective grooves, which are filled with mercury.

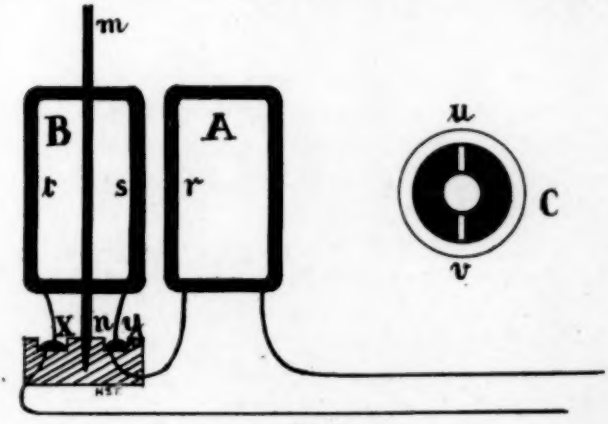
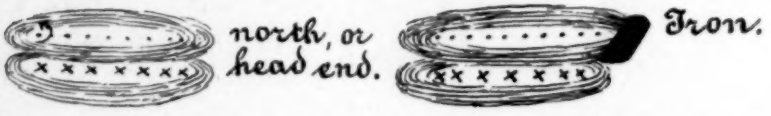


FIG. 4.

These grooves are illustrated by the top view *C* and are so arranged that when the coils are parallel with each other, current is flowing in opposite directions at *s* and *r* respectively. *B* is rotated because of the repulsion set up by the crowded condition of the lines of force, and *t* is attracted. *t* would thus stop near r, but just as it reaches that point, the ends *x* and *y* pass over the bridges *u* and *v* (built of paraffine), reversing the current in the coil *B*, thus insuring continual rotation. The terminals *x* and *y* are double ones, each being made up of two terminals in parallel spread apart slightly more than the width of the bridges *u* and *v*. This will cut out the coil *B* for an instant each half revolution doing no harm thereby, and will prevent the self-induction spark caused by breaking the circuit from fusing the terminals. This experiment not only illustrates these fundamental laws, but may, at the same time, give the pupil a starting point from which to work out the motor and its commutator.

One other fact may be shown from the conditions above. When the current passes the same direction in two parallel wires, we have seen that the field of force encircles both the wires, and that iron seems to be an excellent conductor or retainer of this stress. If therefore, we wind a wire in the form of a solenoid we have an extended condition of the same idea, the combined result of which is that we have lines of force running through the whole coil and returning round the outside.



If now a piece of iron were placed near the end of such a group of parallel lines of force, these lines, like stretched elastic bands, in attempting to manifest their own nature, would pull the iron closer, and if not too large, within the coil. This illustrates so called magnetic attraction, which is nothing more nor less than the lines of force attempting to manifest their own nature. This fact may be illustrated by hanging such a coil by one end, and then holding a large nail near the lower end. It will be lifted out of the hand. A perceptible heating may be felt manifested in the nail which is practically absent when the same experiment is tried with a direct current. This will certainly aid in giving some idea of what takes place within the nail at each alternation of the current, which, as we have previously seen, is accom-

panied by a reversal in the direction of the lines of force sent through the coil and hence through the nail. The vibrations caused by these reversals will also be plainly perceptible to the hand holding it. Magnetism, to my mind, may be made clearer and more real if it were made to follow and not to precede, as in most texts, the experimental evidence of this fundamental property of a current: its field of force.

By some such simple experiments as these, all with "home made" apparatus, I believe nearly all the fundamental properties of the electric current may be easily demonstrated with the city's incandescent or alternating system. It is cheap and very convenient, and a current of some kind is a practical necessity in every school in order that our young people may obtain a clear idea of the subject. As an auxiliary aid in the lecture room, I find it almost indispensable.

Take, for example, one illustration, the arc light. I confess I cannot well get along without it. With it we may accurately illustrate the law of inverse squares, focus and conjugate foci of concave mirrors, laws of reflection of mirrors, not to mention the value of the stereopticon. How to use it to adequately show the laws of reflection of mirrors may need a little further explanation.

We have a tank about five feet long and four broad with a glass bottom. I support this at its ends and place the light and a mirror (either a large concave or plane) beneath in such a way as to reflect the light upward. Placing water in the tank to the depth of about one-half inch, and a piece of wood, held down with a weight, cut, say, in the form of a concave mirror; by touching the water with the end of a ruler at some point as x, representing the position of the object, the waves will proceed to the mirror and be reflected, coming to a point which represents the position of the image. To send parallel rays to the mirror it is only necessary to touch the whole length of the ruler simultaneously. With the electric light below the tank the whole picture is thus magnified and projected upon the ceiling and the whole problem made evident.

PREPARATION OF MAMMALIAN SKELETONS.

By Bertram G. Smith.
University of Michigan, Ann Arbor.

The preparation of mammalian skeletons by a person without experience usually involves a considerable loss of time and material before the precise mode of procedure adapted to secure the best results can be determined. Most text-books on the anatomy of the cat give brief general directions for preparing skeletons, but much is left to be learned by experience. It is hoped that by the use of the following detailed directions a successful preparation can be easily and quickly made at the first attempt. If carried on in the manner indicated, the work is devoid of all disagreeable features. The cat is chosen as an example, but the methods given, with slight modifications, will apply equally well to almost any other mammal.

Unless the operator is already quite familiar with the anatomy of the bones, he should consult in connection with his work the illustrations and descriptions in some good work on the anatomy of the cat, such as Jaynes' Mammalian Anatomy, Reighard and Jennings' Anatomy of the Cat, or Wilder and Gage's Anatomical Technology.

1. *Preparations required.* Each student should have for individual use a set of bones as follows:

(a) One complete skeleton with all the bones disarticulated except the hyoid, sternum, and the bones of the hand and foot of one side.

(b) One articulated skull.

There should also be provided for class use at least one natural skeleton (i. e., a skeleton prepared without disarticulating the bones, or with the bones wired together in the natural position). The cartilaginous parts would, as far as possible, be retained. In addition it is well to prepare several trunk skeletons—articulated vertebral columns with attached pelvis, ribs and their cartilages, and the sternum.

A few skeletons of young kittens should be prepared to show the incomplete development of some of the bones at this stage—particularly bones that develop from several centers, as the innominate bones, humerus, femur, etc. The skulls should be articulated to show sutures, for which purpose they serve especially well; the bones of the hand and foot, at least, should also be prepared articulated.

2. *Selection of Specimens.* For most purposes cats just old enough to be full grown are best—from one to three years old.

In kittens many of the bones are not shown in the completely developed state, and the epiphyses are likely to separate from the diaphyses; consequently such specimens are not good for general purposes. When the kittens are at least half-grown, their skulls do very well for disarticulated preparations; the bones are very easily taken apart, but are not so strong and durable as those of older specimens. The ear ossicles are well developed in kittens, and are easier to extract without injury from a young than from an old specimen.

On the other hand, cats may be too old to be desirable. Aged cats (i. e., those from 6 to 8 years old) often have exostes, or abnormal growths, on their bones. Moreover, the sutures of some portions of the skull may be entirely obliterated, making it impossible to trace them in the articulated skull, and impracticable to separate the bones. The sphenoid is especially likely to be broken in such skulls. The teeth are often missing or decayed. The stapes is brittle and held by tough ligaments. Old cats require a much longer time for boiling before the flesh can be separated from the bones.

For an articulated skeleton, a middle-aged specimen is to be preferred, the larger the better.

3. *Collecting.* The cat can be most conveniently carried to the laboratory in a sack with coarse mesh to admit air. Sometimes it will be found better to kill the cat before its transportation, as a dead cat is more convenient to carry than a live one.

4. *Killing.* Chloroform should be used if the cat is killed in the laboratory. Place the cat in an air-tight keg, jar or box no larger than is necessary, and throw in a handful of cotton saturated with 3 or 4 teaspoonfuls of chloroform; cover tightly and hold the lid down while the animal is passing through the stage of intoxication. The cat will be dead in about 15 minutes. If cats are to be killed away from the laboratory, drowning is a convenient method and free from all objections except some slight discomfort to the cat. Place the cat in a sack and hold it under water for a few minutes.

5. *Removal of Skin.* The work is more easily done soon after the animal is dead, before *rigor mortis* sets in. Place the animal on its back on a large dry-goods box or table; stretch the limbs laterally at right angles to the body and fasten in that po-

sition by cords attached to the paws by slip-knots and tied to nails driven into the box or table, one at each corner.

With a sharp scalpel make a longitudinal incision through the skin in the median line just posterior to the point of the chin. Introduce a grooved director into this cut and with the grooved side upward push it just below the skin along the median line toward the tail. The skin can now be easily divided by pushing the point of the scalpel along the groove of the director. In this manner the skin should be divided along the ventral side in the median line until the tail is reached. Then starting at the median line, divide the skin of each leg in a similar manner.

In removing the skin, lift up the cut edge with the fingers of the left hand, thus putting the superficial fasciæ on the stretch and with the scalpel held in the other hand divide the loose tissue lying in the angle between the skin and the body. Remove as much fat as possible with the skin.

In removing the skin care must be taken not to injure the hyoid and the clavicles. The clavicles are best located and removed at this time, and tied up in a piece of cheese-cloth.

After the skin has been reflected about the anus, put the skin on the stretch, dissect the rectum free from the surrounding pelvis as far as possible, and tie to prevent escape of contents of intestine. Cut the skin posterior to the ligature. This procedure will assist in the later removal of the intestine, and is much better than to tie and divide the rectum within the body cavity as is usually directed.

It will not be necessary to remove the skin from the hands, feet and the tip of the tail, as it will come off more readily after boiling.

6. *Removal of Viscera.* Beginning at the tip of the xiphisternum and extending posteriorly to the pelvis, make a longitudinal incision into the body cavity. Divide the œsophagus and trachea; avoid cutting the larynx, as the hyoid may be injured thereby. Cut the diaphragm free from its attachment to the body wall, insert the hand into the thoracic cavity, tear the contents free from the thoracic walls and pull them together with the windpipe and œsophagus backward and out through the incision in the abdomen. Separate the mesentery fastening the abdominal viscera to the dorsal body wall, free the rectum from the pelvis and pull it forward, thus removing all the viscera.

7. *The Liquid Soap Method of Cleaning the Bones.* This

method, first recommended by Wilder and Gage, is best for the preparation of skeletons from fresh material. Specimens preserved in formalin or alcohol are not easily prepared by this method.

The cleaning is done by boiling the bones in a dilution of the following mixture:

Distilled or rain water, 2000 c. c.
Concentrated ammonia, 150 c. c.
Potassium nitrate, 12 g.
Hard soap, 75 g.

The advantages of this method are the rapidity of the process and freedom from the disagreeable odors attendant upon the old maceration method. The liquid soap saponifies the fat and aids in softening the connective tissue. The bones come out white and free from grease. It is especially adapted for skulls, as the teeth are much less likely to fall out than with the maceration method, and the gelatinized dental periosteum, serves as a cement, when it dries. There is no danger of blood poisoning if fresh healthy specimens are used.

Use a porcelain or granite-ware kettle to avoid discoloring the bones.

8. *Preparation of Set of Bones for Individual Use.*

(a) *Boiling and Cleaning.* After skinning the cat and removing the viscera and clavicles, cut away as much of the flesh as is convenient with a sharp knife. Remove the head, being careful not to injure the hyoid apparatus. Separate the limbs from the trunk, and sever the tail from the body at the union of the first caudal vertebra with the sacrum. Separate the vertebræ of the sacral and lumbar region from the thoracic vertebrae. Fasten together the limbs of the right side, which are to be used for articulated preparations of the hand and foot, with a string which may be allowed to hang out over the edge of the kettle, so that these bones may be easily removed for examination during the process of boiling. It is best to make disarticulated preparations of the hand and foot of the left side, since the bones of this side are illustrated and described in great detail in Jaynes' Mammalian Anatomy.

It is best to attempt only one skeleton at a time to avoid any possibility of mixing the bones. There is no loss of time after the first boiling.

Place the bones in a kettle with enough liquid soap solution in four parts water (1:4) to cover them. Boil just enough so that the skin of the paws may be readily removed with the forceps. This will usually take from 20 to 40 minutes, according to the age of the specimen. Remove the right hand and foot; the hand should have the radius and ulna attached, and the foot may be left joined to the tibia and fibula. As the bones will be too hot to handle, they may be cooled by immersion in lukewarm water. Remove the hyoid without disarticulating, by dissection with forceps and the small blade of a dull knife. Also remove the sternum entire, by cutting the lateral cartilages connecting it with the ribs. Pour off the liquid from the remaining bones and replace by an equal amount prepared in the same way. Boil again from one-half to three-quarters hour, or until the greater part of the flesh readily comes off from the bones. Meanwhile clean up the articulated hyoid, sternum, hand and foot without further boiling. This is best done with forceps and a small-bladed dull knife. Care should be taken not to injure the ligaments of the joints of the bones of the hand and foot. These will be greatly swollen, so that it will be impossible to make a neat looking preparation at the time it is cleaned; but the ligaments will shrink greatly while drying, so that the appearance of the preparation will be greatly improved. After it is dry, any remaining flesh or rough projections of cartilage may be removed with a knife.

Take the bones from the kettle and by means of the hands, a dull knife, and a nail brush, remove as much of the flesh as will come off easily. Fasten the vertebræ on a copper wire without disarticulating. Remove the ribs one by one, laying them in order on a board as removed, and fasten each set together in order with a string. Stir up the brain with a wire, taking care not to injure the projecting tentorium, and rinse out as much as is convenient with hot water. If the skull is to be prepared without disarticulating, remove the mandible at this time without separating its two rami, and clean up without further boiling. If boiled longer the mandible is likely to come apart at its symphysis. Wrap and tie each set of the remaining bones in cheesecloth and cover with a fresh solution of liquid soap. This time it is well to make the solution stronger—say one part of liquid soap to two parts water.

Boil the bones until the soft parts may readily be removed

with a nail brush. This will usually take from one-half to three-quarters hour. If the skull is to be prepared without disarticulating, care should be taken not to boil it too much, as some of the bones, particularly the lachrymals, nasals and malars, also the teeth, are likely to become loose and fall out. Hence a skull intended for this purpose should be carefully watched, and after 15-30 minutes boiling it is usually advisable to remove it from the kettle and clean it up. The brain should be thoroughly removed with forceps, wire, and by rinsing with hot water. The ear cavity should be carefully cleaned with forceps and rinsed with water by means of a pipette, and the malleus and incus removed with delicate forceps. Keep a record of the side from which each set of ear bones is obtained. The stapes is best removed with a hooked pin; it is very delicate and easily lost or crushed by careless handling. Great care is required to avoid pushing it into the cavity of the internal ear; if this is done it usually cannot be recovered.

Clean up the pelvic girdle at the same time as the skull. It is well to leave the ossa innominata united at their symphysis, and further boiling is likely to separate them.

The other bones should be boiled until the work of cleaning with a brush can be carried on with the greatest ease. Time is lost by attempting to clean them too soon. The phalanges may be kept in order by placing each bone as soon as separated from the rest in a box with numbered compartments.

If the bones are not entirely free from grease boil them again, excepting the articulated preparations, in liquid soap solution 1:1 for about half an hour. Rinse them thoroughly in clean water and place them on white paper to dry in the sun. This will bleach them sufficiently. The drying should be thoroughly done.

(b) *Disarticulating Skulls.* Boil the skull, prepared as directed above, from one-half hour to an hour in liquid soap 1:1. If the specimen is young, the bones may now be separated by steady pulling with fingers or forceps. In the case of an older animal, it may be necessary to fill the cranial cavity with peas, beans or rice, force a cork into the foramen magnum, and soak the skull for a few hours. This will burst apart the dorsal sutures and the process of disarticulation may then be completed by hand. Especial care is necessary to avoid breaking the sphenoid, the ethmoid, and the maxillo-turbinals, and to avoid losing the lachrymals.

(c) *Cements for Bones and Teeth.* Teeth that become loose during boiling will often be found firmly fixed in place after the skull is dry, hence only teeth that remain loose after drying need be reset. For this purpose, use plaster of Paris. Bones that have come apart at their symphyses may be fastened together with liquid glue.

(d) *Labeling.* Assign a number to each set; this number should be placed upon each bone or articulated preparation, and upon each box, tray or vial containing bones of the set. In the case of bones too small to label, as the ear ossicles, sesamoid bones, etc., seal up the vial containing the bones; the number on the vial will then be sufficient. All very small bones should be kept in vials, to prevent loss or injury. The body vertebræ and the first four caudal vertebræ may be strung in order on a wire. The labeling of the bones with the number of the set should be done with water-proof India ink; in case it is desired to use numbers to indicate the order of arrangement of any of the bones, as the ribs, vertebræ or phalanges, these numbers may be distinguished by using red ink or Roman numerals. Vials containing ear ossicles, and boxes containing the manus or pes, should be labeled right or left.

9. *Boxes for Skeletons.* The set of boxes specified below is intended to contain a set of bones for individual use.

The outside box and trays, with covers, should be made of heavy pasteboard, covered with black cloth and lined with paper. Compartments of trays should be made of separate complete paste board boxes without covers, glued in place. The boxes and trays trays may be numbered and labeled with white ink.

The outside measurements of trays should be adhered to; measurements of compartments make no allowance for thickness of material.

(a) Box to contain trays specified below. *Inside* dimensions 31 cm, x 17.5 cm. x 12.5 cm. Telescope cover.

(b) Three trays as follows: (1) Tray to contain bones of disarticulated skull. See Fig. 1. *Outside* dimensions 30 cm. x 16.5 cm x 3 cm. The covered spaces may be used for posting notices or records of inspection.

The ear ossicles are best kept in small vials, in the same compartment with the temporal bones. The lachrymals should also be kept in a vial, and placed with some other bone. The ethmoid may be placed in a short shell vial, or wrapped in tissue

paper. The vomer should be left attached to the ethmoid, the maxillo-turbinal to the maxillary.

(2) Tray to contain limb bones (except the larger bones,

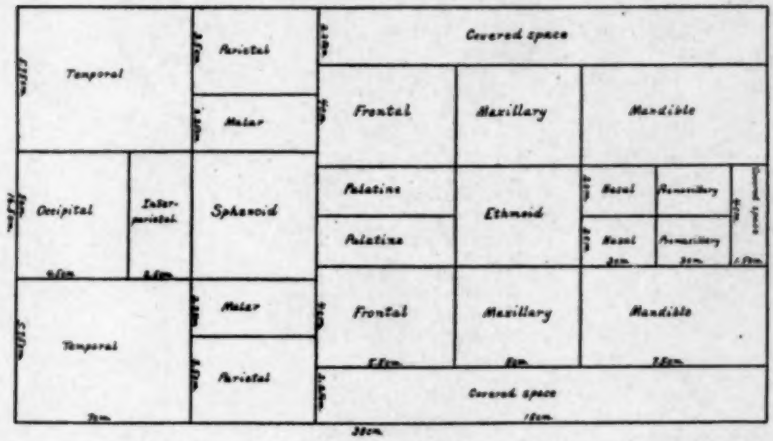


Fig. 1

such as the femur, humerus, pelvic girdle, etc.). See Fig. 2. *Outside* dimensions 30 cm. x 16.5 cm. x 3 cm.

(3) Tray to contain articulated skull and remaining bones. See Fig. 3. Outside dimensions 30 cm. x 16.5 cm. x 6 cm. The clavicles, chevron bones, and the small vertebræ of the tip of the tail, are best kept in vials; the articulated hyoid may be kept in a shell vial.

Fig. 2.

The trays should be provided with hinge covers, each consisting of two flaps attached at the longer sides of the trays.

10. *Preparation of Natural Skeletons.* A skeleton held together by the natural ligaments may be prepared by boiling for only a short time in liquid soap solution 1:4 (about one-half to three-fourths hour, depending on the age of the specimen—about as much as was recommended for articulated hands and feet.) Clean up the preparation as well as possible without injuring the ligaments, taking great care not to dislocate any of the bones by

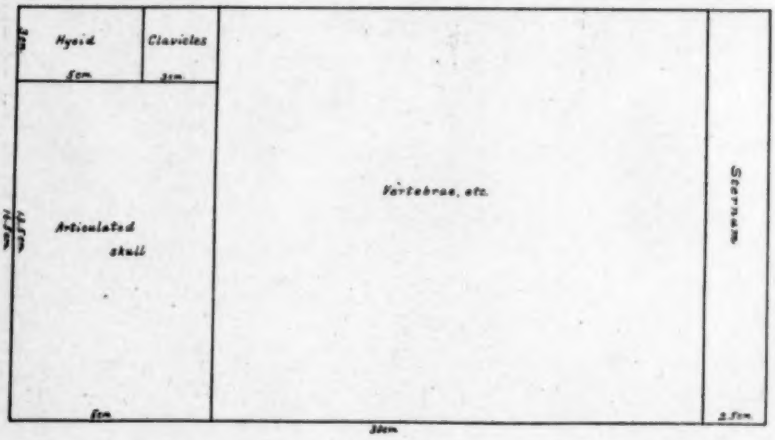


Fig. 3.

careless handling; then soak for 3 to 6 hours in a saturated solution of sodium arseniate (about 25 per cent) to poison the ligaments and protect them from insects. Then arrange the parts in a natural position and support the skeleton with wires. When the preparation is dry and the previously swollen ligaments are shrunken, finish the process of cleaning by trimming with a sharp knife.

If it is desired to have the ligaments flexible, soak the preparation, after it is partly dry, for 12 to 16 hours in a mixture of saturated solution sodium arsenate 4 parts, and glycerine 1 part.

Preparations made by first disarticulating the bones of the body, thoroughly cleaning and then wiring them together, are troublesome to prepare and are best purchased from a dealer in natural history supplies.

11. *Preparation of Bones of Kittens.* The liquid soap process is best for this purpose, but the boiling should be carried little

further than for the making of a natural skeleton. Ten or fifteen minutes boiling is sometimes sufficient for a young kitten. The bones must not be boiled until the epiphyses separate from the diaphyses.

OUT-DOOR WORK BY THE PUPIL ON HIS DAILY TRIPS TO SCHOOL.

By D. R. Ellabarger,
Richmond, Ind.

It is quite unnecessary for me to say in the beginning, that if there is any educational value in the study of biology, it is in the fact that it cultivates the habit of accuracy. Whether a pupil is to become a botanist, or a book-keeper, a bank-clerk or what not, makes no difference. The training he gets in the biological laboratory will be of the greatest value. An accurate botanist or zoologist will be accurate wherever he is.

But there is danger, especially when classes are large and a teacher's time is limited, that scientific observation be confined to the tables of the laboratory alone. It is altogether possible for a pupil to do good work in the laboratory, hand in good note books and yet know but little of his daily surroundings. A pupil may be able to describe accurately a plant laid before him on the laboratory table and not be able afterward to recognize the same plant in the woods. I have had pupils who could point out the difference between the leaves of the sugar and silver maples and yet were not able to tell these trees apart on the street. In other words, a pupil may be a fairly good observer of things through a lens or microscope and yet be a poor observer out of doors.

Twenty years ago the teaching of botany in this state consisted chiefly in plant description and identification by means principally of the flower. That was the kind of botany taught me and however much it may have been condemned, yet the so called "analysis of flowers" was a delightful study. I would make long journeys into the woods and along lake shores and river valleys that I might have the pleasure of finding a specimen new to me. That was the way I taught botany and I had my pupils watch for the first spring flowers just as the Audubon people are now doing with the birds. Now it may be that the old way of teaching botany or the old matter that was taught, was not so scientific as more modern methods and subject matter, yet they had at least

one virtue, and that is, they took the pupil out into the woods. If the only object the pupil had was to find a new flower and a new name, yet he learned unconsciously its habitat, could tell you exactly where to look for others like it and could recognize others as far as he could see them.

Then came the days of the microscope and stains and paraffin, etc., and instead of sending the pupils out into the woods we had to make sections for them and show them cells and they had to draw and describe from the microscope.

Now while the cell is the unit of structure, and while it might seem that there would be the logical place to begin the study of biology, yet a knowledge of cells is not what pupils of high school age should know about first. It is more important that any one should know first the place where liverworts grow and how they look when they are growing and where one may expect to find them than to know how great a differentiation has taken place among its cells or what is its life history.

I have known college students who have worked out the whole of the life history of Marchantia and had never seen the plant growing in its native haunts. I remember well my experience with Nostoc. I worked it out in the laboratory and thought I was well acquainted with it, but it was long after I had finished it before I found it and when I did find it, didn't know what it was.

But this is not such a bad thing among college or university students for they have or ought to have a large background of scientific observation upon which to base their laboratory work, even if it be on plants other than those upon which they are working, but for high school pupils of the first year it does make a difference, for we must remember that on account of their extreme youth for one thing, they have no background upon which to work and in the larger towns and cities they have but little opportunity to learn anything about plants and animals from actual observation.

It is more important first that high school pupils be able to know mosses or ferns and be able to know where to find what plants they want than to know what is meant by the alternation of generations. In other words it is of *first* importance that high school pupils know the natural history of a large number of plants than their life history. Their laboratory work will then have meaning.

Now what can be done in any high school to cultivate to a greater or less degree the habit of observing things outside the laboratory? I can only give my experience, what I have and am doing and about the only thing possible with a hundred and forty pupils in botany and a programme of seven periods per day.

In the fall of the year, for about two months or so long as the weather permits, we study trees. I have a blank form for tree description, much like the old flower description blanks that were used years ago. We have a good many trees on the school lot. I take the sections of the class out for their period of time allotted on the programme. I work with them, tell them exactly what to do and see that each pupil does exactly what he is told to do. For example, we practice measuring the heights of the trees. Of course with the crude methods that must be used in measuring, accurate heights cannot be obtained but one will often be surprised at the accuracy pupils acquire after very little practice. After we have had some experience in this, I tell them to judge the heights before measuring and then verify or correct their judgment by measurement. Then we take up the other steps in the outline such as the bark, leaves, sap, fruit, etc. Each pupil has pencil and tablet and makes the briefest kind of notes from which he is expected to write a complete description. In the laboratory I give them notes on the commercial value of each tree, such as the use of lumber, sap, or fruit, and discuss with them the value of each tree as a street tree. We also discuss methods of tree pruning, for in these days of telegraph and telephone wires we find that trees are sometimes pruned with more regard for industries than to increase the beauty of the tree.

There are some days of course when we have to stay in the house on account of bad weather and on such days we write up our notes and learn to identify the specimens. Then when we have described all of the trees on the lot, we begin with those on the street around the block. Of course we find some like those we have had, but it requires as close observation to discover this as if they were unlike those described. In a similar manner we are able to describe the trees around four blocks and yet get back to the school building on time.

Then each pupil is required to bring in a check list of the trees around his home block and the descriptions of any new ones that may be found there. Then he is required to make a list of all the trees he passes on the street along his regular route to and from

school. Several times I have been able to make out a fairly complete check list of all the trees in our city streets, from the lists prepared by the pupils.

When they are able to work quite independently and rapidly, I have the programme arranged so that I may take the sections of the class, one at a time, to the woods. In ten minutes from the time we get a street car we are in the woods in a river valley where we can see the trees growing in their native surroundings and can in an elementary way see how plants are influenced by their surroundings.

I try to make the subject as practical as possible and the parents and citizens have become interested. Our mayor told me that if we would recommend a list of trees that were good street trees he would see that an ordinance be passed prohibiting the planting of any other kind in our city streets. But the thing that is of greatest value is the habit which the pupil acquires of looking at things intelligently. I have had pupils who have gone out of school tell me that they never ride through the country that they are not trying to make out what the trees are which they see in passing.

I do not know what can be done in other subjects to cultivate this habit but good work may be done by pupils on their journeys to and from school in observing the street trees. Of course there are many other things to which attention may be called. The unicellular plants that we study is the Pleurococcus, which grows abundantly on the bark of trees and by the time we get around to that, the pupils know from their own observations something of its habitat, where to look for it, how it looks growing and that it may be had in fresh condition at almost any time of the year.

One need not expect much from high school pupils if they are sent out alone and told to observe, but if they are given a certain thing to do such as making out a list of the trees on a certain street, one will get fairly good results. If one gets one class started in this kind of work, the plan is established for in some way the habit is passed along to the next class before it reaches you.

Let me say in conclusion, that there is no one thing that helps me so much with my indoor work as this habit which the pupils may acquire of seeing things which they pass every day.

HOW TEACHERS OF PHYSICS ARE "MADE IN GERMANY."

By E. A. Strong,

Ypsilanti, Michigan.

In the September number of *Zeitschrift fuer den Physikalischen und Chemischen Unterricht* Professor E. Wiedemann of Erlangen gives, at the request of the management of that journal, his notion of the best university preparation for teachers of physics in the middle schools—gymnasia, real schools, etc. Those who wish to know about the preparation of teachers for the public schools (primary schools), and especially how the law of 1901 affected this matter, will find an admirable French view of the whole subject now running in *Revue Pedagogique,* beginning with the September number.

Prof. Wiedemann justifies the association of physics with mathematics in the secondary schools, as is done in Germany, instead of the French practice of combining physics and chemistry, or physics with other sciences. He would, however, have intending teachers give some attention to chemical physics and become familiar with precipitation, filtration, crystallization, etc., and with the preparation of oxygen, hydrogen, carbon dioxide, etc. In mathematics he would have the candidate become familiar with analytical geometry; the calculus, especially in its applications to physics; analytical mechanics; differential equations; and the theory of functions. Especially he would have him know elementary mathematics thoroughly and fundamentally, including the beginnings of the non-euclidean geometry.

He also justifies at considerable length the elementary course in descriptive physics given to intending teachers, along with those looking forward to other professions, at the beginning of their university course. It is true that students coming from the oberrealschulen and realgymnasien can truly say, "We have heard all that before." Well, if they choose let them cut the lectures and have a good time; but those who attend will find that they have added much to their knowledge and understanding of the subject. They will hear to know and not, as previously, to be prepared for examination. They will get a more connected view of the subject, unobstructed by a multitude of applications. Above all they will form physical concepts directly from the physical world without the intervention of mathematical symbols and formulæ. So their knowledge will be real and not merely formal, as is

likely to be the case if they go forward at once to theoretical physics. Students who are satisfied with purely formal definitions and who lean constantly upon the mathematical expression of physical ideas will, when they come to teach, be satisfied that their pupils have the same hollow semblance of knowledge. There is not time in the schools, often not the opportunity or the incentive to ponder the great things of physics, to let them sink into the mind and be really penetrated with them; so that the impression that physical subjects make is relatively weak and soon forgotten, as every university man knows. The schools all greatly misjudge as to the amount of abiding, well-digested, and utilizable knowledge which their students carry away with them. Especially is this true of the simplest concepts, which, just because they are so simple, are also so difficult.

Following this semester of descriptive and demonstrative physics two semesters of lectures are given upon theoretical physics, in which the chief stress is placed rather upon the physical content than upon the mathematical relations. This should give the students some ability to read original researches, where the mathematical demands are not too great, and some preparation for an "Arbeit" of their own. Lectures are also given upon particular departments of theoretical physics; upon the history of physics; and upon recent developments in the more important branches of the subject. Some practice is had in soldering, glass blowing, etc., and in preparing material for demonstration; though the writer does not think it worth while for the students to make complete pieces of complicated apparatus. The practical work is more exacting than that given to other students. Special attention is given to the experiments of the secondary schools: as—index of refraction, accurate weighing, etc. Great stress is placed upon the density of gases, for its manipulative value; but the densities of solids and liquids by different methods, specific heats, and a number of other problems, are worked hastily and with no very high degree of accuracy, so as to give time for some more advanced measurements:—as, the dielectric constants, polarization angles, heat of neutralization, elevation of boiling point, heat of combustion, etc.

In Bavaria the examination for intending teachers is divided into two parts: one after the fourth and one after the eighth semester. For the second part a scientific arbeit is demanded. Concerning the value of this arbeit to a teacher there has been

much discussion, but the writer thinks it equal in value to a dissertation in mathematics and justified by the fact that skill in using apparatus is always useful to a teacher.

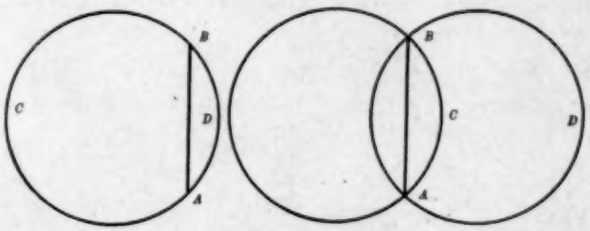
Upon suggestion of the government officials they have hit upon the following scheme:

Themes, mathematical and physical, such as will come up for discussion in the schools, are distributed among the candidates. Those who specialize physics may get mathematical themes, and conversely. The candidate then has to treat the subject in a manner corresponding to the underlying knowledge and the power of comprehension of pupils and with apparatus such as he would use in early experimental work. Some one or other of the candidates will be able to prepare such apparatus, or it may be kept in stock. The point of these expositions does not lie in the correction of much formal awkwardness in presenting the experiment and analyzing it upon the blackboard, but in abundant instances of want of clearness—indeed of gross errors in comprehension—which come to light and may be corrected. They find the criticism of their fellow students useful, while the one who conducts the exercise gets a view of how much physical knowledge, which he had taken for granted, is really a sealed book to many young people.

A COMMUNICATION.

EDITOR SCHOOL SCIENCE AND MATHEMATICS:

In Milne's Plane and Solid Geometry, Book II, Proposition I, Cor. (Section 193), I see this statement: "In the same circle, or in equal



circles, arcs whose extremities can be made to coincide are equal." Is this true? In the following figures do not arcs ACB and ADB meet the requirements of the hypothesis? Yet they are evidently unequal.

Yours truly,

O. L. PLUNKETT.

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Solutions and problems will be duly credited to the author. Address all communications to Ira M. DeLong, Boulder, Colo.

ALGEBRA.

36. *Proposed by P. G. Agnew, Washington, D. C.*

Coal is on the deck and coal is running on the deck from a chute at a uniform rate. Six men can clear the deck in an hour, eleven men can clear it in twenty minutes. How long will it take four men to clear the deck?

Solution by William Bucke Campbell, B.S. in E., Philadelphia, Pa.

Let x = fraction of quantity on deck originally removed by one man in one hour,

y = fraction added from chute in one hour,

q = quantity on deck originally.

From the given conditions, $q + y - 6x = 0$, $q + \frac{y}{3} - \frac{11x}{3} = 0$, whence $x = \frac{1}{8}q$, $y = \frac{1}{4}q$. Let z be the number of hours for four men to clear the deck, then $q + \left(\frac{1}{4}q - \frac{4\times 2}{5}q\right)z = 0$, and $z = 5$.

37. *Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

A man can go to a place by two routes. The shorter route can be made by rail in 6 hours, by boat in 20 hours, and on horseback in 30 hours. In going he takes the shorter route and travels an equal number of hours by each conveyance. He came back by the longer route and traveled as many miles horseback as he had traveled by rail going, as many miles by rail as he went horseback going, and as many miles by steamer as by both rail and horseback. What was the total time consumed in traveling and what is the ratio of the lengths of the routes?

Solution by F. M. Dryzer, B.A., Knoxville, Tenn.

If shorter route, s, can be made by rail in 6 hours, then $\frac{1}{6}$ can be made in one hour. Similarly, $\frac{1}{20}$ by steamer and $\frac{1}{30}$ by horse. Or, in 3 hours $\frac{1}{6} + \frac{1}{20} + \frac{1}{30} = \frac{1}{4}$ can be finished. Hence 12 hours are required for making the trip, and in portions of 4 hours each:

Rail $= \frac{1}{6}s$. On return $\frac{4s}{6}$ ÷ rate by horse, $\frac{s}{30} = 20$ hrs.

Horse $= \frac{8}{15}s$. On return $\frac{2s}{15}$ ÷ rate by rail, $\frac{s}{6} = \frac{1}{2}$ hrs.

Boat $= \frac{s}{5}$. On return $\left(\frac{4s}{6} + \frac{2s}{15}\right)$ ÷ rate by boat, $\frac{s}{20} = 16$ hrs.

Sum total of hours $= 12 + 20 + 16 + \frac{1}{2} = 48\frac{1}{2}$; Ratio 1: $\frac{1}{6} + \frac{1}{12} + \frac{8}{15} =$ 1: $\frac{17}{8} =$ 5:8.

GEOMETRY.

38. *Proposed by L. M. Saxton, Edgewater, N. Y.*

Given ABCD as any parallelogram, E any point in AB, F any point in DC. Join E with D and C, and F with A and B. Let AF meet DE in Y, and BF meet CE in Z. Let the line YZ produced meet AD in P and BC in Q. Prove that PQ divides ABCD into two equivalent parts.

Solution by I. L. Winckler, Cleveland, O.

Let PQ, produced, meet AB and CD, produced, at K and L respectively.

Then in triangle ABF we have $ZF \cdot KB \cdot AY = BZ \cdot KA \cdot YF$.....(1), and in triangle CED, $YD \cdot LC \cdot EZ = EY \cdot LD \cdot ZC$.....(2), since a line cutting the sides of a triangle determines upon the sides six segments, such that the product of three non-consecutive segments is equal to the product of the other three.

Also, the triangles BEZ and AEY are similar, respectively to triangles CZF and DYF.

Therefore, $BZ : EZ = ZF : ZC$ and $EY : AY = YD : YF$.

From these $BZ \cdot ZC = ZF \cdot EZ$..... ....(3)

and $EY \cdot YF = YD \cdot AY$.....(4)

multiplying together (1), (2), (3), (4) and canceling common factors we get $KB \cdot LC = KA \cdot LD$.....(5), but $KB = KA + AB$ and $LD = LC + CD$, substituting these in (5) $(KA + AB) \cdot LC = (LC + CD) \cdot KA$.

Reducing $AB \cdot LC = CD \cdot KA$ and since $AB = CD$, $LC = KA$. Therefore, triangle KAP = triangle QLC and AP = QC. Therefore, BQ = PD.

Then area trapezoid ABQP = area trapezoid CDPQ.

MISCELLANEOUS.

39. If sin A, sin B, sin C are in harmonical progression, so also will be $1 - \cos A$, $1 - \cos B$, $1 - \cos C$; $A + B + C = 180°$.

Solution by R. S. Pond, Marietta, Ohio.

By hypothesis $\frac{1}{\sin A} + \frac{1}{\sin C} = \frac{2}{\sin B} = \frac{2}{\sin(A+C)}$. Expanding and clearing of fractions

(1).....$\sin A \sin C \cos C + \cos A \sin^2 C + \sin^2 A \cos C + \sin A \cos A \sin C = 2 \sin A \sin C$.

If $1 - \cos A$, $1 - \cos B$, $1 - \cos C$ are in harmonic progression

$$\frac{1}{1-\cos A} + \frac{1}{1-\cos C} = \frac{2}{1-\cos B} = \frac{2}{1+\cos(A+C)}.$$

Expanding cos (A+C), clearing of fractions substituting $\sin^2 A = 1 - \cos^2 A$ one obtains the equation (1).

CREDIT FOR SOLUTIONS RECEIVED.

Problem 32. John W. Scoville, I. L. Winckler.
Problem 33. I. L. Winckler.
Problem 34. I. L. Winckler.
Problem 35. I. L. Winckler.
Problem 36. T. M. Blakslee, Henry A. Converse, R. S. Pond, S. R.

Schoels, John W. Scoville, I. L. Winckler, F. E. Woodruff, Esther M. Venables, E. A. Buck, P. G. Agnew. Three incorrect solutions were received.

Problem 37. Glenn L. Allen, T. M. Blakslee, E. L. Brown, R. S. Pond, S. R. Scholes, I. L. Winckler, Benjamin Elkind, F. E. Woodruff, Esther M. Venables, A. D. Greenlee, H. C. Whitaker.

Problem 38. T. M. Blakslee, E. L. Brown, L. M. Saxton.

Problem 39. T. M. Blakslee, E. L. Brown, I. L. Winckler, R. S. Pond.

Total number of solutions, 36.

PROBLEMS FOR SOLUTION.

ALGEBRA.

44. *Proposed by W. H. Hays, Columbia, Mo.*

A cow is tied to one corner of a house, which is 20′ x 30′, with a 60 ft. rope. Find the area over which she can graze.

GEOMETRY.

45. *Proposed by John W. Scoville, Syracuse, N. Y.*

Four spheres, each of radius r, are arranged in a pyramidal pile, each sphere touching the other three. What is the inside surface of a box shaped like a regular tetrahedron, that will just enclose these spheres?

46. *Proposed by T. M. Blakslee, Ph.D., Ames, Ia.*

Prove by elementary geoemtry that the midpoints of the three diagonals of a complete quadrilateral are collinear.

APPLIED MATHEMATICS.

47. *Proposed by Wm. B. Borgers, Grand Rapids, Mich.*

A bicyclist coasting down a 6 per cent grade due west finds the acceleration of gravity just counteracted by the wind, producing uniform motion. He then turns 30 degrees north, where the grade becomes 10 per cent. The direction and velocity of the wind being still the same, still produces uniform motion. Find the direction of the wind.

PACIFIC COAST ASSOCIATION OF CHEMISTRY AND PHYSICS TEACHERS.

The winter meeting of this association will be held the last week in December in connection with the State Teachers' Association at Fresno, Cal. The following program has been prepared:

Mathematics of Elementary Chemistry,
J. U. Keran, Prin., Fowler Union School.

Whitherward in Chemistry?
H. F. Sheldon, Prin. Armijo Union High School.

Light by Wave-front Method,
A. L. Cavanagh, Los Angeles High School.

Physics, C. E. Crane, Fresno High School.

The officers are, President, A. N. Sheldon, White's Preparatory School, Berkeley; Vice-President, Miss Margaret Scott, Haywards; Secretary-Treasurer, A. G. Vangorder, 2141 Center Street, Berkeley, Cal.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The sixth annual meeting was held at the University of Chicago November 30 and December 1, 1906.

The general sessions were held in Mandel Hall. At the opening session Friday forenoon the resignation of Charles M. Turton as secretary was read and accepted. After various announcements an address of welcome was given by Professor R. D. Salisbury in behalf of the University. This was followed by papers by Professor Lyman C. Newell, Boston University; subject: "Profit and Loss in Experimental Chemistry" (this paper will be printed in full later), and by Professor William M. Davis, Harvard University; subject: "The Value of Scientific Studies in the Cultivation of Various Mental Faculties."

The afternoon was given to section meetings. The evening was devoted to an informal reception at the Reynolds Club, a dinner at Hutchinson Commons and an address by Professor John F. Woodhull, Teachers' College, Columbia University. Subject: "Science for Culture." (This will be printed in the February number of this magazine.)

The annual business meeting was held Saturday morning at 8:30. The secretary reported the most prosperous year in the history of the association, 142 new members having been elected. Two flourishing local centers were organized during the year, at Jacksonville, Ill., and at Des Moines, Iowa (the Central Iowa Association of Science and Mathematics Teachers).

A committee was appointed to consider the advisability of forming a section in Industrial Education and to report at the next meeting.

Article X of the constitution was amended by substituting "one dollar and fifty cents" for "one dollar" wherever used in connection with "School Science" and "official organ."

The article relative to membership dues was changed so as to read, "two dollars and fifty cents" instead of "two dollars," this change to apply to all dues paid after July 1, 1907, provided that persons already subscribers to SCHOOL SCIENCE AND MATHEMATICS shall pay only such portion of the dues as belongs to the association and is retained by it. The following amendment was also adopted: That the office of secretary and treasurer be combined and that there be an assistant secretary-treasurer. That the secretary-treasurer give a bond for $1,000, the expense of said bond being paid by the association, said bond to be approved by the executive committee. The term of office of the secretary-treasurer to be three years. The assistant secretary-treasurer to be elected annually. All bills must be approved by the executive committee and signed by the president and the chairman of the physics section before being paid.

St. Louis was made the place of the 1907 meeting.

The following report of the treasurer and auditing committee was read and approved:

RECEIPTS.

From E. M. Williams, former treasurer	$123.89
From 357 members	558.34
Advertisements in 1905 program	118.00
Nine advertisements in 1906 program (to date)	70.00
Sale of reports on correlation	2.75
Collection on checks refunded by members	.20
Total	$873.18

EXPENDITURES.

Publishers SCHOOL SCIENCE AND MATHEMATICS '06 and '07	$256.65
Publishers SCHOOL SCIENCE AND MATHEMATICS, '05	7.00
Printing and typewriting	61.50
Printing, 1905 account	41.13
Postage and stationery	24.86
Expenses—	
President, secretary and section officers	60.59
New physics movement committee	16.69
Local center committee	15.00
Office supplies for treasurer	4.35
Printing and mailing programs, 1905	98.40
Printing and mailing programs and circulars, 1906 (All bills not yet received.)	62.95
Badges, 1906 meeting	15.00
Collection and bank fees	1.80
Express	2.20
Rent of Y. M. C. A. cloak room, 1905	1.75
Total	$669.87
Balance cash on hand	203.31
Total	$873.18

SUMMARY.

From former treasurer	$123.89	
From back dues	6.00	$129.89
1905 bills paid		48.13
Net amount from former treasurer		$81.76
From dues	552.34	
For subscriptions S. S. and M. $256.65		
For bank fees .60	257.25	
Net receipts from dues		295.09
From advertisement in 1905 program	118.00	
For expense on 1905 program $98.40		
For collection slow account 1.00	99.40	
Net profit on 1905 program		18.60
From 9 advertisements in 1906 program	70.00	
For partial expense 1906 program	62.95	
Net partial profit 1906 program		7.05
From sale of reports on correlation		2.75
Total net receipts from above five sources		$405.25

For postage, stationery, printing, officers' and committee expense	182.99	
For sundries	18.95	
Total running expenses		201.94
Balance cash on hand		$203.31
Net amount received from former treasurer	81.76	
Total receipts of present treasurer	$743.29	
Total expenditures present treasurer	621.74	
Net receipts	121.55	
Balance cash on hand		203.31

The auditing committee desires to report that it has examined the books of the treasurer and finds them correct.

We congratulate the association in having the services of Mr. Parsons in instituting business-like methods for keeping the accounts of the association. We found a very admirable system.

We desire also to commend the report of the treasurer, particularly in regard to the classification and summary of the receipts and expenditures. We recommend that the report be published in SCHOOL SCIENCE AND MATHEMATICS, and that a similar report be required of future treasurers for publication.

W. WHITNEY,
MINNA C. DENTON,
F. T. JONES, Committee.

The following officers were elected: President, C. E. Comstock, Peoria, Ill.; Sec.-Treas., C. W. D. Parsons, 320 Main Street, Evanston, Ill.; Ass't Sec.-Treas., S. A. Douglass, Central High School, St. Louis, Mo.

The report of the committee on the proposed National Federation of Science and Mathematics Teachers Associations was approved. The committee was continued and the members were authorized to act as delegates to the coming meeting in New York. Adjourned.

C. M. TURTON, Secretary.

CHEMISTRY AND PHYSICS SECTIONS.

The chemistry and physics sections held a joint session Friday afternoon in Ryerson Laboratory, at which the following papers were read: "Standards in Science Teaching," by Franklin T. Jones, University School, Cleveland, O. Mr. Jones' paper will be printed in full in a subsequent issue of SCHOOL SCIENCE AND MATHEMATICS. This paper was followed by a most interesting discussion. "Applications of Principles in Physical Science," Professor John F. Woodhull, Teachers' College, Columbia University. Quoted Professor Hall that a "capacity for a quick understanding of machinery" is necessary. Referred to increasing attention to applications in text-books and on programs of meetings of teachers of physics and chemistry. Said we need not fear the imputation of commercialism, but claimed that the only way to have the principles understood was to teach them with reference to their applications. Unless we do this we are little better than book

scientists. Our artificial laboratory experiments will not save us from the charge of being impractical, academic, unable to understand conditions in nature. A number of illustrations were given as to how certain topics in physics and chemistry should be treated. Would like to call it a course in common sense, in constructive imagination, in phenomenology. "Report on Course of Experiments in Physics," Professor C. R. Mann, University of Chicago. Professor Mann, chairman of the Committee on the Physics Syllabus, reported at length for the committee. The substance of the report follows:

The original work of the committee was "to report on matters of interest from the physics section of the National Educational Association and confer with the committee of that body on a physics syllabus, and such other matter as may need attention."

The committee found that the work of the National Educational Association committee did not meet the present needs of the physics teachers, and set before it the task of finding out as nearly as possible what the teachers wanted. The work of the committee along this line has resulted in the sending out of four circulars.

Circular I asked for a vote on a long list of experiments named by the committee, and a statement concerning the justification of their use. After the sending out of this circular, the members of this committee became associated with a much larger committee of the North Central Association of Colleges and Secondary Schools, whose business it was to define the unit in physics.

This larger committee, realizing that the most lasting results could be accomplished only when the whole country was represented, has invited all important associations interested in this subject to appoint committees to co-operate in the work. More than a dozen associations have complied with the request, and a number have not yet reported.

In order to better deal with the broader features of the educational problem, the North Central Association, which had power to add to its membership, invited a number of prominent educators to join that body. The following accepted the invitation: Mr. P. H. Hanus of Harvard, Mr. John Dewey of Columbia, Mr. G. H. Mead of Chicago, and Mr. M. V. O'Shea of Wisconsin.

Circular II reported the returns of Circular I, and also contained some further questions on the methods of conducting laboratory work, the aims of the course, and the uses of associations in general.

The third circular contained, besides the summary of the answers to Circular II, a set of ten theses which were put forth as suggested subjects of discussion.

A fourth circular has just been issued. This contains suggestions as to the definition of the unit and a portion of a new syllabus. The definition of the unit in this circular contains many new features. Perhaps the most important is that it allows the teacher greater freedom in the conduct of his work than any hitherto printed. The arrangement of the syllabus has been worked out after a careful study of many American syllabi and of those recently adopted in France and Germany.

"The Point of View in Chemistry," by Professor Alexander Smith, University of Chicago. This paper will be presented in full in a future number.

"Quantitative Experiments in Chemistry," by W. D. Baker, Shortridge High School, Indianapolis, Ind. The gist of Mr. Baker's paper is here given.

Quantitative conclusions should be reached by—

1. Skillful questioning of the student on his past experiences.
2. Careful measurements by the student under the guidance of the teacher.
3. Careful measurements (experimenting) by the teacher before the student.
4. Study of the careful measurements of the masters of the subject.

As to "relative emphasis" in these methods be suggested—

1. Increasing attention to deriving quantitative conclusions from questions based on every-day experiences.
2. That only "useful information" is desired.
3. That quantitative experiments by teachers be made more prominent.

"Some Practical Applications of the Electrical Furnace," by Mr. F. G. Taylor, High School, Oregon, Ill. Mr. Taylor gave a brief talk on the electric furnace, and showed how a simple furnace could be constructed by the use of ordinary electric light carbons and fire bricks. By using such a simple furnace, Mr. Taylor reported that he had been able to produce quick lime from marble, illuminating gas and coke from soft coal, and calcium carbide from lime and coke. Samples of some of the products of the electric furnace were shown.

At the business meeting Saturday morning, the following officers were elected for the ensuing year: Chemistry Section—Chairman, G. A. Abbott, Manual Training High School, Indianapolis; Vice-chairman, Miss Jessie F. Caplin, Central High School, Minneapolis; Secretary, H. D. Abells, Morgan Park Academy, Morgan Park. Physics Section—Chairman, H. N. Chute, High School, Ann Arbor, Mich.; Vice-Chairman, C. H. Slater, McKinley High School, St. Louis; Secretary, Franklin T. Jones, University School, Cleveland.

After the business meeting both sections met with the American Physical Society in the lecture room of Kent Laboratory.

Saturday afternoon was devoted to a trip to the works of the By-Products Coke Corporation at South Chicago.

EARTH SCIENCE SECTION.

Each of the three section meetings were of exceptional interest.

At the section meeting on Friday afternoon Prof. William M. Davis of Harvard University discussed the need of better laboratory work in physical geography and followed his preliminary remarks with the introduction of a series of lantern slides illustrating, in part, material for a laboratory manual, which he has thus far

found no time to complete. In his general remarks concerning the obvious need of a more sequential and comprehensive kind of laboratory work in this science, Prof. Davis said that the demand had been increased by the acceptance of the laboratory notebook by such colleges as recognize physiography in their entrance requirements; but judging from the materials presented by many candidates for admission at Harvard, and approved by their teachers, the general quality of laboratory work in schools throughout the country leaves much to be desired on the part of both teacher and pupil. The way of escape from such a condition can probably best be provided by having such teachers as find time prepare outlines which may be submitted to others for use and criticism.

Prof. Davis emphasized the use of a more definite terminology in geographical literature, illustrating by the effect which lack of such an aid to accurate description produces in the writings of most authors of books of travel. Such terms as "mountain," "plateau," "valley," serve very well for purposes of general description, but fail utterly as the media of scientific exposition. The plan of terminology which Prof. Davis would suggest as being at once most logical and susceptible of general application uses origin of the land form as the starting point. In such a scheme rock-structure is the first characteristic to be considered; then the agencies of erosion to which it has been subjected, and finally length of time during which they have acted.

The objection will at once be made that this is a geological way of describing a geographical thing; but these sciences are too closely related to admit of an arbitrary separation. Geography is only a temporary stage of historical geology. The geological history of the earth is composed of a succession of landscapes—or we might call it a complete file of geographic journals, of which we happen to be most concerned with the last number. Since, therefore, geography is, as it were, only a horizontal section across the vertical succession of landscapes which together make up geology, and inasmuch as surface features of the earth depend for their form on their structure, normal weathering and stage of development, we must make use of these determining geological factors in devising an appropriate geographical vocabulary.

The slides which Prof. Davis presented showed eight diagrams from his unpublished manual which illustrated the development of the coastal plain. The general plan in this set of exercises is to lead the pupil by slow steps through the various stages in the life history of this type of land form, carefuly proceeding from the known to the unknown by appropriate exercises of the faculties of observation and inference. Form is made more graphic by the employment of contour lines, skill in the use and interpretation of which, however, the pupil gains as *a secondary acquisition*, and only after the real need for them has developed. The relation of structure to form is revealed by examination of the edges of layers composing the coastal plain, laid bare in the sides of the deeper valleys, by reference to records of well borings and railroad cuts, and to examples given in the text and elsewhere.

The influence of weathering upon form is made clear by studying the headward growth of gullies, the development of stream branches, and the widening of valley floors by flood-plain growth.

The increasing complexity of stream systems with age of the plain, and the synchronous diminution of the upland surface emphasizes the importance of stage of development in determining surface form.

After the address, numerous questions were raised and a most profitable hour spent in general discussion.

Dr. Charles E. Peet gave a supplemental report for the Committee on Co-operation. This committee had been continued from last year. The committee reported that a list of five hundred books of travel suitable for pupils studying physical geography had been selected and mimeograph copies prepared for distribution. Teachers desiring such list and willing to assist the committee in testing the selection may obtain it by addressing Dr. Charles E. Peet, Lewis Institute, Chicago. Owing to the practical nature of the work and its possibilities for genuine co-operation the committee was continued.

A committee of three was appointed to collect data as to the actual work accomplished in physiography in the territory of the Association and report at the next meeting. Teachers should lend a willing hand when called on by this committee.

Saturday at 10 A. M. Dr. Goode gave an illustrated lecture on "Chicago's Commercial Advantage of Position." This lecture was a fine example of Dr. Goode's well known ability for effective illustration of his subject, logic of presentation, clearness of statement, and oneness of purpose in making his point. He stated that it is true of cities as of men that "some are born great; some achieve greatness; and some have greatness thrust upon them." He then proceeded to show that Chicago's position made it impossible for her to escape greatness.

The election of officers at this session resulted as follows: For chairman, Miss Annie Weller, Eastern Illinois State Normal School, Charleston, Ill; for vice-chairman, Mr. Seth Hayes, High School, Dayton, O.; for secretary, Mr. Walter S. McGee, Hyde Park High School, Chicago.

Saturday at 1:30 P. M., a party left Walker Museum to visit the Chicago Normal School and the Wendell Phillips High School. Through the courtesy of the Chicago Board of Education, the principals of these schools, and the teachers of geography, the equipment of the schools for the teaching of physical and commercial geography was open for inspection of visiting teachers. The party thoroughly appreciated the opportunity thus offered, and found many suggestions in the excellent equipment of these schools.

The work of the Bureau of Geography operating under the direction of the Department of Geography in the Chicago Normal School was of especial interest. Through it, small traveling museums consisting of specimens, pictures, and printed matter are sent to all the schools of the city requesting them. These museums bear directly on a particular topic in the geography work. Many teachers of the city regard them as the best helps they have in making geography work concrete.

MATHEMATICS SECTION.

The meeting was opened by the chairman, Mr. J. V. Collins of Stevens Point, Wis.

Prof. H. E. Cobb of Lewis Institute, Chicago, spoke on "Personal Observations of Teaching of Mathematics in German Schools." He called attention to the fact that an understanding of the school system in Prussia depends upon an understanding of the life there, and to the fact that the system as a whole is subject to change much more generally than is commonly supposed, and that in mathematics, reforms are now in progress that are along lines similar to reforms now in progress in this country. He gave a list of references on Germany, the German school system, and the teaching of mathematics in German schools, and showed a number of charts giving interesting statistics.

Dr. J. W. A. Young of University of Chicago spoke on "Current Tendencies in Secondary Mathematics in Italy and France." Changes were made in the curricula of classical schools of Italy in 1904. In France changes were made in 1901, 1902, and 1906. The changes in 1906 were an outgrowth of the changes of 1902. In both countries increased time was given to mathematics, and the educational authorities recommended less abstract and more concrete work, more attention to applications and to graphic methods and a closer correlation of the various branches of secondary mathematics. Dr. Young strongly recommends the simultaneous teaching of arithmetic, algebra, and geometry.

A discussion then took place on the following questions: Has not the correlation of algebra and geometry been tried in this country? Do not our conditions in this country effect results?

Prof. E. B. Skinner of University of Wisconsin spoke on "The Teaching of Mathematics in Wisconsin. He said that in general pupils came to the university and especially to the scientific schools of the university inadequately prepared in algebra. To meet this condition the university was giving an examination in algebra after entrance. Students who failed to make satisfactory grades were obliged to take a special course in algebra. These conditions he laid to three causes: (1) Algebra is usually given in the first year of the high school with no review in later part of the course; (2) Too many subjects are taught in the high schools; (3) In small places the tenure of office of teachers is too short, teachers teach too many subjects and have little or no interest in mathematics. He recommends that some algebra be taught in later part of high school course, and that the curricula of high schools be simplified, and he hopes that universities and normal schools may have more influence on small places.

Prof. H. L. Coar of Marietta College, Marietta, O., spoke on "The Teacher of Mathematics." He had found that conditions similar to those that Prof. Skinner reported from Wisconsin held generally elsewhere. The preparation of the teacher of mathematics is very often quite inadequate. Universities, colleges, normal schools, and local school authorities could do much to better conditions.

A general discussion followed on methods in the teaching of all branches of mathematics and possible means of improving conditions.

SATURDAY A. M., DECEMBER 1.

Mr. H. B. Loomis, principal of Hyde Park High School, Chicago, sent a paper on "Changes in Teaching of a Course in Mathematics that Will Aid in Keeping Boys in High Schools." As Mr. Loomis was unable to be present, his paper was read by Mr. E. E. Hill of Hyde Park High School. The paper discussed the first year work in algebra. Mr. Loomis recommends that equations and problems be made the basis of this course, rather than abstract manipulation as now. He recommends generalized arithmetic, the derivation of formulæ as generalizations from special cases and only such abstract work as is needed for problems and equations. Really practical problems are needed. Until these can be obtained we must make use of such problems as we have. In selecting problems it is necessary really to keep within the pupil's experience. "The material demands of a practical age are actually forcing better pedagogy on abstract mathematics."

Miss Elizabeth McConnell of Shortridge High School, Indianapolis, Ind., led the discussion. The following points were brought out: Keeping boys in school is not so much a matter of what we teach as how we teach it. There is sometimes too much sentimentality about keeping boys in school. It is prevention vs. cure; when a boy is determined to leave, cure is difficult; prevent his getting to this point if possible. We expect too much of pupils; what we expect to-day is exactly what was expected of pupils four years older fifty years ago when algebra and geometry were university studies.

The following resolution was passed:

Resolved, That it is the sense of this meeting that the more abstract demonstrations and the more complex manipulations which it may be necessary to include in the high school course in algebra be deferred as late as possible.

The report of the committee on the teaching of geometry was read by Prof. G. W. Greenwood of Dunbar, Pa., chairman of the committee. The report discussed the proper introduction of definitions, the nature and treatment of geometrical assumptions, and the use and misuse of figures. It recommended parallel courses in construction and demonstration, experimental verifications to accompany or precede actual demonstrations, historical notes, advanced courses in geometry, and the omission of useless theorems.

Moved, seconded, and carried, that the report be received and that the committee be continued.

Moved, seconded, and carried, that we recommend to the executive committee that this report be printed and circulated as widely as possible.

Moved, seconded, and carried that a committee be appointed by chairman to present at the next meeting a similar report on the teaching of algebra. The following persons were placed on the committee: C. N. Ammerman of McKinley High School, St. Louis, Mo.; Mabel

Sykes, South Chicago High School, Chicago, Ill.; I. S. Condit, State Normal School, Cedar Falls, Ia.; Elizabeth McConnell, Shortridge High School, Indianapolis, Ind.; C. W. Newhall, Shattuck School, Faribault, Minn. The committee was ordered to print the report and circulate it a month before the meeting.

The following officers were elected for next year: Chairman, Dr. H. E. Slaught, University of Chicago; Vice-chairman, Prof. J. C. Stone, Ypsilanti, Mich.; Secretary, Mabel Sykes, South Chicago High School, Chicago, Ill.

MABEL SYKES, Secretary.

ARTICLES IN SOME CURRENT MAGAZINES.

Popular Science Monthly for December: "The Bogoslofs," President David Starr Jordan and George Archibald Clark; "The Development of the Telephone Service," Fred DeLand; "Physical Degeneracy or Race Suicide?" Sidney Webb; "Waterway Defenses of the Atlantic Coast," William J. Roe; "The Value of Science," Professor H. Poincaré; "Vesuvius in the Early Middle Ages," Dr. Charles R. Eastman.

Technical World for December: "Pipe Line Across Panama;" "Secret Wireless Telegraphy;" "From Peat to Paper in Two Hours;" "A Spool of Wire Speaks by Means of the Telegraphone."

Science, November 2: "The Concurrence and Interrelation of Volcanic and Seismic Phenomena," Angelo Heilprin. November 23: "The University and the World's Great Workshop," John A. Brashear.

School Review for November: "Science in Civilization and Science in Education," C. R. Mann; "Books Old and New in Mathematics," H. E. Slaught.

Farming for November: "Controlling Bovine Tuberculosis," Frederick Bonsteel, photograph by Herbert E. Angell; "What Denatured Alcohol Will Really Do for the Farmer," George S. Hall.

Scientific American, November 10: "Carl Hagenbeck's Novel Zoological Park." December 1: "Machine for the Commercial Production of Window Glass by the Sheet Process."

Scientific American Supplement, November 24, December 1 and December 8: "How Seeds Are Carried."

Monthly Weather Review, July: "The Waterspout Seen off Cottage City, Mass., in Vineyard Sound, on August 19, 1896."

More than 1,000 students and teachers are enrolled in the Washington state college at Pullman, south of Spokane, and it is believed by President Anderson that every department will be overtaxed before the Christmas holidays. This surpasses all records, and indicates that the enrollment will reach 1,200.

THE TEACHING OF GEOGRAPHY.

All geography teachers would profit by reading the address on the Teaching of Geography, delivered at the opening of the Geographical Exhibition in Edinburgh, July 6, 1906, and published in the *Scottish Geographical Magazine* for September, 1906. The following is an extract from the address:

"A moment's reflection will enable anyone to realize that geographical conditions have largely determined historical change in the past, and that the historical conditions existing at the present can be made completely intelligible only through the prior understanding of the geographical relations. Again, and above all, a full knowledge of the geographical facts is necessary for the right understanding of the economic and the commercial conditions of our own and other countries. For the localization of a people and the distribution of their industries within any one country and throughout the world generally can be made thoroughly intelligible only when geography teaching has clearly realized this as its ultimate aim, and when the knowledge has been imparted to the pupil according to a sound method. As the final result of our teaching of geography, we should have made our pupils realize not merely that a certain city or town is placed here or there, but why this is so; not merely that it has such and such industries, but why these industries are located here and not elsewhere; and lastly they must understand the use and function the particular city plays in the economic and social life of the nation and of the world generally. Only in so far as we have done this can we be said to have taught the subject at all."—*T. C. H.*

BOOK REVIEWS.

List of Laboratory Experiments in Physics for Secondary Schools. Recommended by the University of Chicago. By Robert A. Millikan, Assistant Professor of Physics in the University of Chicago, and Henry G. Gale, Instructor in Physics in the University of Chicago. Ginn & Company, New York and Chicago. Price, 40 cents.

This book represents the laboratory work of "A First Course in Physics" which has been developed during the past four years for the use of the high school department of the School of Education and for other secondary schools affiliated with the University of Chicago. The author's aims in the development of this course have been: 1. To incorporate that which is most essential and to eliminate that which is unessential to the awakening of enthusiasm for the study and interpretation of familiar physical phenomena. 2. To select and modify experiments in such a way as to reduce the cost of laboratory equipment to a minimum, in the hope of enabling even the financially weaker schools to introduce a thorough laboratory course. 3. To incorporate only such experiments as experience has shown to be workable with large classes and with a minimum tax upon the teacher's time outside his laboratory hours. The book accordingly presents a definite course of fifty carefully devised and selected experiments representing the author's ideals of what is most essential to a proper development of the subject, and most practicable for the average secondary school.

Special Experiments and Discussions in Introductory Chemistry, with a Plan for the Organization of the Subject Matter. By Eugene P. Schoch, Ph.D., University of Texas. D. C. Heath & Co., Boston. 1905. Pp. 62.

This most excellent and unique little book was "intended primarily as a set of suggestions for arranging the material found in texts and laboratory manuals so as to make the work more systematic and intensive. As the discussions ordinarily found in texts are in some portions not adequate, it thus became necessary to write the Special Experiments and Discussions, which form the main part of the book."

The book is divided into two parts, "A Plan for the Organization of the Subject Matter," and "Special Experiments and Discussions." This part discusses the following topics: "Evolution of the Atomic Weight Table," "Bases and their Action with Acids," "Facts and Conditions that Govern Metathetical Reactions between Acids, Bases, and Salts," "The Action of some General Reagents," "Outline for the Separation and Identification of the Common Metals," "Action of the Common Acids upon Metals," "Action of Nitric Acid as an Oxidizing Agent," "Action of Concentrated Sulphuric Acid as an Oxidizing Agent," "The Action of Acids upon the Sulphides of Metals."

The book is intended to be "put into the student's hands to round out and amplify properly the contents of his text and laboratory manual." It is full of valuable hints and suggestions and should be in every chemical laboratory. C. M. T.

The Theory of Functions of Real Variables. By James Pierpont, Professor of Mathematics in Yale University. Pp. xii + 559. Ginn & Co., 1906.

It is perhaps as much as can reasonably be expected of the undergraduate student of calculus, considering the small amount of time usually given this subject in American universities and the rather meager equipment with which he begins the subject, that he learn how to perform the processes and get some acquaintance with the methods, by and large, of calculus. We may well look to graduate study for a fundamental examination of the real meaning of its processes and methods and for a critical study of the conditions and limitations of their legitimate application. At least, this is the procedure in German universities, and for many of us this is as yet sufficient reason for doing likewise in American schools.

A very serious disadvantage to post-graduate work of the variety suggested above has hitherto been that the student has been compelled to ransack European literature on Analysis to acquaint himself with the points of view of the best thinkers in this domain. This book brings together in advantageous form for study all that is necessary to enable a reader to pass his first knowledge of this subject under a critical review and to reconstruct it into a more intelligent and a sounder instrument. This book is heartily commended to all high school teachers, who have already had the customary American college course on differential and integral calculus. To such persons its convenient form, its philosophy and its admirable logic will appeal most forcefully. The typography is, of course, excellent.

Elements of Analytic Geometry. By Percey F. Smith, Ph.D., Professor of Mathematics in the Sheffield Scientific School, Yale University, and Arthur Sullivan Gale, Ph.D., Instructor in Mathematics in Yale College. Pp. xii + 424. Ginn & Co. 1904.

The titles of the thirteen chapters of this book are: Review of algebra and trigonometry, cartesian co-ordinates, the curve and the equation, the straight line and the general equation of the first degree, the circle and the equation $x^2 + y^2 + Dx + Ey + F = 0$, polar co-ordinates, transformation of co-ordinates, conic sections and equations of the second degree, tangents and normals, relations between a line and a conic, applications of the theory of quadratics, parametric equations, the general equation of the second degree, Euclidean transformations with an application to similar conics, inversion, poles and polars —polar reciprocation, cartesian co-ordinates in space, surfaces, curves, and equations, the plane and the general equation of the first degree in three variables, the straight line in space, special surfaces, transformation of co-ordinates, different systems of co-ordinates, quadric surfaces and equations of the second degree in three variables, and relations between a line and a quadric, applications of the theory of quadrics.

The first chapter is a rigorous "trimming up" and formulation of those parts of elementary algebra and trigonometry that are fundamental to analytics. It would constitute an admirable finishing discipline for a class in either algebra or plane trigonometry. It is a review from a profounder point of view than could be given before a class has the field of ideas pretty well before it, but when this is the case it could "clear the air" beautifully for the learner.

Considerable gratuitous fussiness fattens without greatly enriching for the beginner the contents of the next half dozen chapters. Let normal school teachers of mathematics henceforth beware of too great fear of the word "equate," for it is here recognized as having good standing.

The Euclidean order of definition and theorem is followed in a way and though the learner is advised to "boost" himself along by aid of the figure, he is cautioned "not to depend on the figure." In the reviewer's opinion the pitfalls are not numerous enough in this elementary work to vindicate to the student the justice of the caution. It would seem that when there is no sufficient internal evidence of the need of such caution, it is better to hang out no scarecrows. The book is, however, excellently illustrated, and the student will find frequent need of depending heavily upon the illustrations. My advice would be, "Fear not, let him do so freely."

On the whole, the book, from the viewpoint of pure mathematical theory, is an admirable treatment of the elements of the subject and is a distinct contribution to American text-book literature, if the phrase may be permitted on the ground that it conveys an idea. If there had been less struggle for finality of treatment and fewer subjects chosen for treatment, any loss of scientific merit that might have ensued would have been more than counterbalanced on the score of greater teachableness. Any teacher of beginning classes in analytics

will make a mistake if he does not have this text among the half dozen most convenient American texts on his book-shelf.

The publishers deserve more than a word of commendation for the excellence of their workmanship on the mechanical part of the book. Typography, pagination, and general make-up are such as to exhibit the work of the authors in its most enticing form.

Laboratory Astronomy. By Robert Wheeler Willson, Ph.D., Professor of Astronomy in Harvard University. Pp. ix + 185. $1.25. Ginn & Co., 1905.

This book deserves more than passing notice. It is one of those rare books that is the direct fruit of class-room experience, by a teacher who knows full well the crying need of the time for beginners in the study of astronomy.

It is not because astronomy is thought to be unsuitable to high school boys and girls that it has been so generally dropped from secondary curricula. It is because the stupid ways of teaching the subject, that were in vogue a few years since, deprived the subject of both its educational and scientific value. Instead of acquainting pupils with the moon and sun and their movements by studying the things themselves, we required them to read and to memorize what others said about them. Good teachers, of course, always have devised ways and means of inducting beginners into the study of the celestial objects and motions directly. But good teachers have always been in the minority. School officers urged that other matters were of more value to the average boy or girl than were the rehashed results of scientific inquiry through pure text-book memoriter.

But for the willing teacher, who still has a chance to bring to secondary pupils the inspiration of astronomical study, the many ingenious devices of this book, and the numerous exercises that are worked out in exemplary fashion, will make the way to better things plain and easy. The apparatus called for can either be reproduced at no expense, or can be had at only nominal cost. With this book a really scientific course—a genuine laboratory course—of astronomical work, running through a whole year, could be easily carried out in secondary schools, and we venture to say with as good or better results than commonly come from the same amount of time spent on biological courses now given. The book was evidently intended for beginning classes in college; but, I dare say, Professor Willson will agree that the main reason for giving it in college is because pupils can't get the opportunity to do such work in secondary courses. At any rate I am herewith urging it upon the consideration of high school teachers, as being the best material yet available for their classes.

To a book such as this, so well calculated to rehabilitate astronomy as a highly educational subject for secondary pupils, so fully in accord with modern educational doctrines, and so stimulating as it would be to the scientific tyro, too great publicity cannot be given. It is a most valuable contribution to scientific text-book literature, and is warmly commended to the studious attention of all teachers who are friends of science and scientific methods of study.

The publishers have done an important service to education by putting this book in such excellent form. G. W. M.

Elementary Woodwork for Use in Manual Training Classes. By Frank Henry Selden. Cloth binding. 214 illustrations. 206 pages, 12.5 x 17.5 cm. $1.00. Rand, McNally & Co., Chicago.

The author is supervisor of woodworking and pattern-making in the University of Chicago. The book is convenient in size, concise and explicit in statement, and clearly demonstrates both by text and illustration the progress of the work from its first stages to the finished product.

To put this treatise in the hands of a class of bright students will relieve the teacher of a vast amount of personal work, as a study of the text and cuts will give them at the outset an intelligent knowledge of the use of tools and the preliminary work of construction. The pictures show them how to use the tools, and the text briefly and clearly explains the process.

The secret of the utility of the book is found in the fact that the author is himself a practical woodworker, having been a careful student of this class of work for more than twenty years.

The subject is conveniently treated in three divisions. The first part consists of a course of class exercises, so simply, clearly, and comprehensively given, and so fully illustrated that neither modification nor addition is necessary for class use. The instructor, thus relieved of much petty detail, is able to do a far higher grade of work and so raise the general class standing.

The second division is a series of supplementary lessons, amply reinforced by illustration and diagram, designed to benefit the more rapid workers. Where this book is used no pupil need ever be idle; for extra work is always at hand and in such complete form that it can be given out without consuming too much of the instructor's time.

The third division is a description of the tools and materials employed in the work. It is not a collection of quotations from tool catalogues and extracts from encyclopedias, but an entirely original text which was written expressly for the grade of pupils for whom the book is designed.

Although mechanical work cannot be learned as well without the personal assistance of an instructor as with one, this book impresses us as being much nearer a self-instructor than any of the correspondence courses we have examined. Indeed, we cannot see why a boy of ordinary ability should not be able, with the aid of this manual, to do very creditable work with the common tools entirely unaided by personal help. It seems to us that the author deserves the credit of giving to boys the first successful home book on woodworking tools.

In comparison with other books designed for the use of boys, perhaps the most noticeable and important feature in this work is the great care the author has used in working his text so as to prevent pupils from falling into bad habits in the use of tools. Later this will inevitably save them much trouble.

In justice to the publishers we make special mention of the exceptionally fine illustrations, clear type, and general excellency of the mechanical work. In these respects the work far surpasses that of any other of its class.

This manual will be especially welcome to teachers who endeavor to have their pupils work out individual problems. Where now the pupils' energies and ideas are dissipated by unnecessary physical exertion because they lack knowledge of proper methods of work, they will be able after studying this book to apply themselves with such directness as to work out their problems successfully. The profuse illustrations of the book by photographic cuts and extremely full and clear diagrams are in some respects the most useful and unique feature of the manual. They would make instruction almost complete without the aid of the text. Apparently, every position which requires illustrating has been carefully photographed by the author and an excellent half-tone engraving made.

We predict that this little volume will have much to do in placing manual training upon a more practical and rational basis. It certainly must tend, wherever used as a text-book, to increased efficiency in this branch of school work.

Principles of Botany. By Joseph Y. Bergen and Bradley M. Davis. Ginn & Co., Boston, 1906. Pages viii and 555.

The study of botany in the secondary schools has been greatly stimulated the past few years by the appearance of several interesting texts. These differ widely in scope and plan, but agree for the most part in an endeavor to give the student something more than the gross morphology and classification of the higher plants. This volume is one of the most comprehensive of its class, and outlines sufficient work for the best equipped high schools, or for an introductory course in colleges. At the same time the book is so planned as to allow series of connected studies for the schools of lesser equipment or devoting shorter time to the subject.

While the general features of "The Foundations of Botany," by the senior author, are retained, there are numerous changes. Externally the book has an improved appearance, due to the lengthening of the page, and the binding in pleasing green cloth. Elimination of the "Flora and Key," together with all laboratory directions has been made possible by the preparation of a laboratory manual designed to accompany this book. The chief addition is the organization of a section devoted to comparative morphology of plants. This part occupies nearly half the book, and is the special work of the junior author. The conservative use of half-tones throughout the volume is to be commended.

Part I. The structure and physiology of seed plants (Bergen). The treatment follows very closely the general plan of the corresponding part of the author's earlier book, though there are numerous minor changes. Fundamental physiological processes are discussed in conjunction with the organs of seed plants.

Part II. Morphology, evolution, and classification of plants (Davis).

"An account of the critical morphology of plants upon which is based their relationship by descent." The author describes in sufficient detail an extensive series of types characteristic of the various levels of plant organization. Emphasis is laid on reproductive processes, especially those illustrative of the development of sexuality and the simpler sporophytes. In harmony with this plan the Thallophytes are given a relatively larger place than the other groups. Concluding each group is a discussion of its evolution, general characteristics, and probable relationships. Special discussions at the close of the part involve such complex subjects as the origin of the seed, development of the flower, evolution of the sporophyte, and degeneration of the gametophyte. These chapters may be omitted at the discretion of the teacher. The author wisely cautions the reader that many of these conclusions are necessarily theoretical, and at best present living plants or animals only illustrate progress made in past, yet his language at one or two places is perhaps over positive. It is evidently only a slip of the pen when he states (page 403) that stomata in *Anthoceros* and in some of the mosses "was the beginning of the elaborate mechanism for chlorophyll work which is developed to such a high degree in the leaves of ferns and seed plants." These general discussions embody the larger conclusions of comparative morphology, and not only stimulate interest, but will serve also to bind together the successive forms studied. A number of new figures and diagrams are presented which will be welcome; one or two of the original drawings, however, are open to criticism, notably Fig. 221 B.

The morphological treatment as a whole is excellent, and the most comprehensive yet given in a text-book of this character. Supplemented by lectures on critical phases this part alone might easily be expanded into a year's work for those institutions desiring a general course in the study of the significance of plant form.

Part III. Ecology and Economic botany (Bergen).

In the earlier chapters the author takes up parasites and carnivorous plants, protection from animals, pollination, seed dispersal, etc. Following the chapter on the social habits of plants, the subjects of plant successions, ecological groups, and plant formations are discussed. In the later portions there is a brief treatment of plant geography, variation, mutation, and the origin of species. The final chapters on plant breeding, and useful plants and plant products, give the student a glimpse of the economic side of plant study.

ROBERT B. WYLIE, State University of Iowa.

Recent Changes of Level in the Yakutat Bay Region, Alaska. By R. S. Tarr and Lawrence Martin. Bull. Geol. Soc. Am., Vol. 17. Pp. 29-64 pls. 12-23.

The attention both of teachers and of the general public has recently been drawn by the San Francisco earthquake to those deformations of the earth's crust which attend the growth of mountain ranges. Many signs of dislocation of the fractured ground have been recorded and photographed, and much data collected, by the California State Earthquake Investigation Commission, whose preliminary report was

published several months ago. It is well known that this earthquake had its origin in a slipping or faulting along a fracture in the rocks, associated in its position and comparable in its results to innumerable prehistoric faultings which traverse the Coast Ranges, and which have collectively kept the mountains alive and sharp featured while the opposed processes of wasting by weathering and erosion were tending rather to subdue them.

An investigation of rare interest, which was reported to the Geological Society of America in December, 1905, by Professor R. S. Tarr and Mr. Lawrence Martin, deals with a similar deformation of recent date along the shores of Yakutat Bay, in southeastern Alaska. Altogether this case of earth warping is the most striking and most thoroughly demonstrated one on record. In the early part of September, 1899, a series of earthquake shocks was felt in the vicinity of Yakutat, which became more frequent and culminated in a very violent quake on the afternoon of the 10th. "The land swayed, the waters of the bay rose and fell eight or ten feet every few minutes, and violent eddies were set up in the harbor, washing into the sea an Indian burial ground at Port Mulgrave, opposite Yakutat. Most of the natives and whites were panic stricken, abandoning their houses and retreating to tents on the neighboring morainic hills." Another violent earthquake took place on the 15th, and smaller shocks continued until the 20th. A party of prospectors who were encamped near the Hubbard glacier on the shore of Russell fjord, near Yakutat bay, had a very adventurous time and barely escaped death from the earthquake waves and from avalanches on the mountain sides.

No scientists visited the region after the earthquake until the summer of 1905, when Prof. Tarr and Mr. Martin came unexpectedly upon marked indications of recent changes of level along the shores of the bay. In the course of the field season they gathered a wide range of evidence to show that the earthquake of 1899 attended a differential uplift or warping of the district whereby many miles of coast line had risen several feet—in some places as much as 47 feet. Locally, also, there was a depression of the shores.

The fact that these marks of recent changes in level were not found by experienced geologists who visited the bay before September, 1899 (*e. g.*, I. C. Russell in 1890 and 1891 and G. K. Gilbert with the Harriman expedition in July, 1899) is sufficient to fix the recency of the uplift. The testimony of natives, who observed many changes in configuration of the shores between successive visits to the bay, before and after the earthquake, adds to the historic certainty of the movement. Of all the more interest, therefore, is the evidence of a strictly geologic and physiographic nature, and of animal and plant life in the affected zone.

Elevated benches, old water marks of the sea, cut by the waves in the headlands before the change of level took place, now stand at various heights above the bay and beyond the reach of the waves. Sea caves and chasms occur, also, containing shingle which is scantily clothed with annual plants and small shrubs. The latter are described as "often rising up and shadowing dead barnacles that still cling to

the walls of the chasm—a new life springing up in the habitat of the old." Elevated pocket beaches lie between the headlands, more or less concealed by shrubbery and trimmed on their outer margins to low cliffs where waves have cut into the shingle structure since the uplift. These afford excellent paths and camping sites. A more peculiar feature is seen in the old alluvial fans which since their elevation have been trenched by the previously aggrading stream and nipped on their outer margins by the waves. New deltas are being built out below and in front of the old, at present sea level. The recency of the uplift is plainly shown in many places where the till exposed along the new shore line has not yet been sufficiently worked over by the waves to form pebble beaches like those of the old shore.

The testimony of animal and plant life in the shore zone is both interesting and conclusive. Dead barnacles are abundant along the elevated strands at various heights above present high tide mark; indeed, they are more thickly distributed and of larger size on the old shores than on the present, where they have not yet become fully established. Mussel shells, so plentiful and so highly colored as to be mistaken at first for blue flowers, still cling to the rocks along the elevated shore line. A pink bryozoan, which belongs below low tide mark, occurs as a bleached white coating to the rock, above high tide mark, wherever the recent uplift amounted to more than ten feet. Fragments of several other sea forms—crabs, star fish, sea urchins, etc., found on the raised shores confirm the belief that they have but recently been raised above tide. On the other hand no traces of rock. weed or other sea plants are to be found. The interval of six years has been long enough, apparently, to allow the complete decay of these species.

Of equal significance is the new flora of the raised beaches—the predominance of annual plants, and the frequent alders and willows with never more than five annual rings. "One willow tree, growing on one of the most perfect of the elevated beaches (hoisted 42 feet), near Black glacier, threatened to prove an exception, for it was 10 feet high and fully 3 inches in diameter. Cutting it down, we found its heart made of dead wood, with four new rings outside. Evidently it was an uprooted tree, thrown there by the earthquake wave, and sprouted in its new location.

In these various ways, then, one may read the recency of the earth movement. Since, moreover, the saplings are equally old on all parts of the raised shore line, no matter at what height it stands, they testify to a single uplift of variable amount, rather than successive local uplifts.

In places the coast has sunk; for along low shores in sheltered bays the salt water is seen to have encroached on forests, killing the trees by mere submergence without uprooting them. In certain places of great exposure forests have been invaded by earthquake waves to the height of 40 feet, and driftwood has been piled high in enormous quantities.

Avalanches shaken down in 1899 have wrought some striking changes in topography. Fault scarps, measuring a vertical displacement of

from a fraction of an inch to three feet, form sharp steps across the ground, intersecting both the till veneered ledges and the bare striated surfaces themselves.

Above this shore line of 1899, in places, are distinct higher terraces and beaches which bear an older growth of forest. The uplift of September, 1899, therefore, is but the latest of a series of mountain building movements which have from time to time renewed and modified the slopes of the coastal topography. JAMES W. GOLDTHWAIT.

BOOKS RECEIVED.

Exercises in Zoology, by Worrallo Whitney and Frederic C. Lucas. Neeves Stationery Company, Chicago.

Good Health, by Frances G. Jewett. Ginn & Co., Chicago. 172 pages.

Manual of Style. University of Chicago Press.

Elementary Experimental Magnetism and Electricity, a combined lecture and laboratory course by William Allanach, B.Sc. (London), Longmans, Green & Co., New York, 1906. Pp. 265. $1.20 net.

Plane and Solid Geometry, by Isaac Newton Failor, Principal Richmond Hill High School, New York. The Century Co., 1906. Pp. 418.

Fairy Stories Retold from St. Nicholas. The Century Co., 1906. Pp. 192.

The Making of an American School Teacher, by Forest Crissey. C. M. Barnes & Co., Chicago, 1906. Pp. 75.

The Directory of Science and Mathematics Associations which has been printed on the first three pages of the advertising section will hereafter be printed only in the October, February and June issues. Use now the directory printed in the October number. Officers and others are requested to keep this Journal informed of any change in the officiary.